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Stennis Space Center, MS 39529-5004

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Current Meter Observations During the Kuroshio Extension Regional Experiment

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Current velocities and temperatures were measured using an array of current meter moorings (CMMs) deployed along a line across the Japan Trench near 35° N, 143° E, as part of the Kuroshio Extension Regional Experiment (KERE). A total of 15 instruments were distributed among five moorings. The resulting time series data describe deep currents as well as the Kuroshio where it separates from the Japanese Coast. The moorings were deployed from July 1992 through June 1994. This report describes the CMM data.

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CURRENT METER OBSERVATIONS DURING THE KUROSHIO EXTENSION REGIONAL EXPERIMENT

Introduction

A major component of the field activities for the Kuroshio Extension Regional Experiment (KERE) is focused on the acquisition and analysis of velocity and temperature time series data recorded by moored current meters (CMs). In this report the collection, processing and preliminary analysis of the CM data are described, and various plots are presented. These data are generally of good quality and constitute a significant contribution to the understanding of the dynamics of the Kuroshio and the deep boundary currents in the KERE region.

The initial cruise was in July, 1992. Five current meter moorings (CMMs) and 10 inverted echo sounders (IESs) were deployed, and 18 conductivity-temperature-depth (CTD)/hydrographic stations were conducted. Forty expendable bathythermographs (XBTs) were dropped at IES sites for calibration purposes. Except for 4 IESs, all moorings and CTD stations lay along a TOPEX/POSEIDON groundtrack. The hydrographic observations included water samples which were analyzed for salinity, dissolved oxygen, silica, nitrate, and phosphate. These hydrographic and XBT observations are discussed by Teague et al. (1993, 1994). The CMMs and IESs were recovered in July 1993 and subsequently redeployed, with the exceptions of CMM A and IESs 9 and 10 which were not recovered. In addition, IES 7 and 8 were not redeployed. With IES redeployment, 26 calibrations XBTs were taken. The four CMMs and the IESs (except for IES 6) were finally recovered in May 1994. There were 12 additional calibration XBTs at the IES sites. IES measurements are discussed in Teague and Hallock (1995).

Background

The primary focus of the CMM field program is the observation of a hypothetical Pacific Deep Western Boundary Current. While there are several indications of the existence of a deep current off Japan (Nan'niti and Akamatsu, 1966; Worthington and Kawai, 1972) the results are not conclusive or statistically significant, as they are for the Atlantic. There is some theoretical basis for such a flow (Stommel and Arons, 1960) but in the absence of a northern source in the Pacific, the sign (northward or southward) of the deep boundary current near Japan is in question. Along the Aleutians, however, an analogous deep northern boundary flow was observed (and reconciled with the model of Stommel and Arons, 1960) by Warren Owens (1985, 1988). Hence, this experiment included the deployment of a line of current meter moorings across the Japan Trench near 35°N, 143°E.

Instrument Description

The CMs used in the KERE were Neil Brown/EG&G ACM-II acoustic current meters. The ACM-II is an internally recording vector-averaging current meter. Its velocity sensor utilizes an acoustic phase-shift technique capable of high accuracy and resolution, which senses two components of horizontal current velocity, relative to the instrument housing. Housing orientation is determined using a saturable-core magnetometer compass. Velocity and compass information is generated by the sensors as analog levels proportional to the components of water current in the sensitive plane of the instrument (perpendicular to axis of the the pressure case) and to the local components of

the ambient magnetic field, respectively. These analog levels are converted to earth coordinates and then digitized and averaged over the sampling interval. Averaged data are then recorded on cassette tape within the instrument housing.

The ACM-II is about 1.5m in length and about 20 cm in diameter, and weighs about 100 lb in air. It is powered by batteries constructed of D-cells (alkaline cells were used for KERE deployments).

Current Meter Data Processing

CM data are internally recorded on cassette tapes. These tapes are normally removed from the instrument at sea. At NRL, data are transferred in hexidecimal format from the tapes to disk files on an IBM-compatible computer (PC) where they are converted to engineering units and ASCII format. These ASCII files are then transferred to a Sun Work Station for further processing and analysis. Each sample in the raw, unedited file consists of 6 variables: time, eastward velocity component (U), northward velocity component (V), temperature (T), pressure (P) and compass (ϕ; the housing orientation). The U and V components recorded in the instrument are horizontal velocity components relative to magnetic north, hence a variation correction is applied (in the PC step) to convert to true northward and eastward velocity components: for KERE, the magnetic variation is -7°. Pressure sensors were present only in 4 CMs.

The first figure is a map showing the locations of the CMMs as well as the IESs (IESs are not discussed further in this report; see Teague and Hallock, 1995). CMMs B and C were inshore of the Japan Trench, D was on the seaward flank of the Trench and E was on the abyssal plain. The second figure shows the vertical arrangement of the CMs on the moorings. On actual moorings (not shown in the figure) clusters of floats (17" glass spheres protected by fiberglass shrouds) were distributed between the CMs. Large, syntactic foam buoys were placed on the top of each mooring, and parallel (pairs) of acoustic release mechanisms were placed below the deepest CMs.

Filled left/right sides of CM symbols represent complete records for first/second year, respectively. CM designators in the figure are used throughout the report; hence, "CM93D3" represents the second year record from mooring D at depth 3000m, etc. A more complete summary of data recovery appears as Table 1. Notice that records CM92E2 and CM93E1 are quite short. In the first, the recorder failed after about 2 months; in the second, the instrument leaked and failed after about 3.5 months. Also note that 4 of the instruments (year 1) did not yield temperatures; this was due to an internal malfunction in the temperature processing circuitry. Only the upper CM on each mooring had pressure sensors (B1, C1, D1 and E1). CM depths (Table 1) are based on mean pressures from upper instruments and the known cable lengths between instruments. This method of estimating CM depth minimizes errors due to stretch of nylon line placed below releases, and uncertainties in bottom depths.

Tables 2 and 3 list basic statistics of recorded parameters. Table 3 differs from Table 2 only for velocities (U, V); Table 3 is for "offset corrected" velocities (discussed below). An overbar (e.g. $\overline{U}$) indicates a time average and σ indicates a standard deviation. $\overline{S}$ and $\overline{\theta}$ are the speed and direction of the mean velocity. The relatively large σ_P values for the D1 and E1 records (as well as the large pressure ranges (P_{min} and P_{max}) indicate significant mooring motion as a result of the flow in the thermocline. Analysis shows (not presented here) that direct contamination of velocities by horizontal movements of CMs as a result of mooring motion is minimal. However, the vertical excursions of the D1 and E1 instruments, through the high vertical shear in the thermocline, introduces some spatial aliasing to these records. Correction for this effect is not discussed here. The vertical aliasing due to mooring motion is not important for the remaining, deeper instruments since the vertical shear is much less, as are the vertical excursions of these

CMs.

Most temperature records exhibited bias errors which may be caused by CM internal register malfunctions for most-significant bits. Hence, CTD data were used to provide a constant correction to each record. Standard deviations appear to be acceptable, but further, small adjustments (following this report), based on post-calibration results, will probably be made. $\overline{T}$ for CMs 92B2, 92D2, 92E2 and 92E4 (the instruments which did not yield temperature records) are just the CTD values for those locations (these are indicated by asterisks in Table 2 and 3).

A number of the velocity records exhibited anomalies that suggested zero offsets in instrument coordinates. Scatter plots of U vs V yielded a "donut"-shaped cloud rather than a Gaussian cloud about the mean value. When transformed back into instrument coordinates (using ϕ), the "donut" characteristic was no longer present, and the offset was apparent as the center of the cloud, off the origin. By subtracting weighted averages of instrument-coordinate components from the instantaneous values, an offset correction was effected. The corrected instrument-coordinate components were then transformed back to earth coordinates, and these appear in Table 3. For the offset correction scheme to be valid, two criteria must be met: there must be "adequate" variability of ϕ, and that variability cannot be significantly correlated with the real velocity components. If these criteria are not met, then fictitious calculated offsets may result. Hence, while offset-corrected velocities for all records are presented in this report, as well as the uncorrected velocities (for reference purposes and additional considerations of the problem), in subsequent analyses, offset-corrected data should only be used when the uncorrected data are obviously contaminated (e.g. when a data set shows anomalies such as the "donut" distribution). For the KERE data, offset-corrected velocities should be used for the following records: 92C1, 92C3, 92E4, 93C2, 93C3, 93D3, 93E4.

Tidal and inertial energy are significant components of the variability in all CM data. Since much of subsequent analyses will focus on lower frequencies, it is useful to present the data with the higher frequencies removed. The second set of plots show low-pass filtered velocities, with half-amplitude point at 40 hours.

Data Plots

Plots of all time series appear after Table 3 as follows: U and V components (raw); U and V components (raw; offset-corrected); U and V components (low-pass filtered); U and V components (low-pass filtered; offset corrected); Pressure (P); Temperature (T).

Acknowledgments

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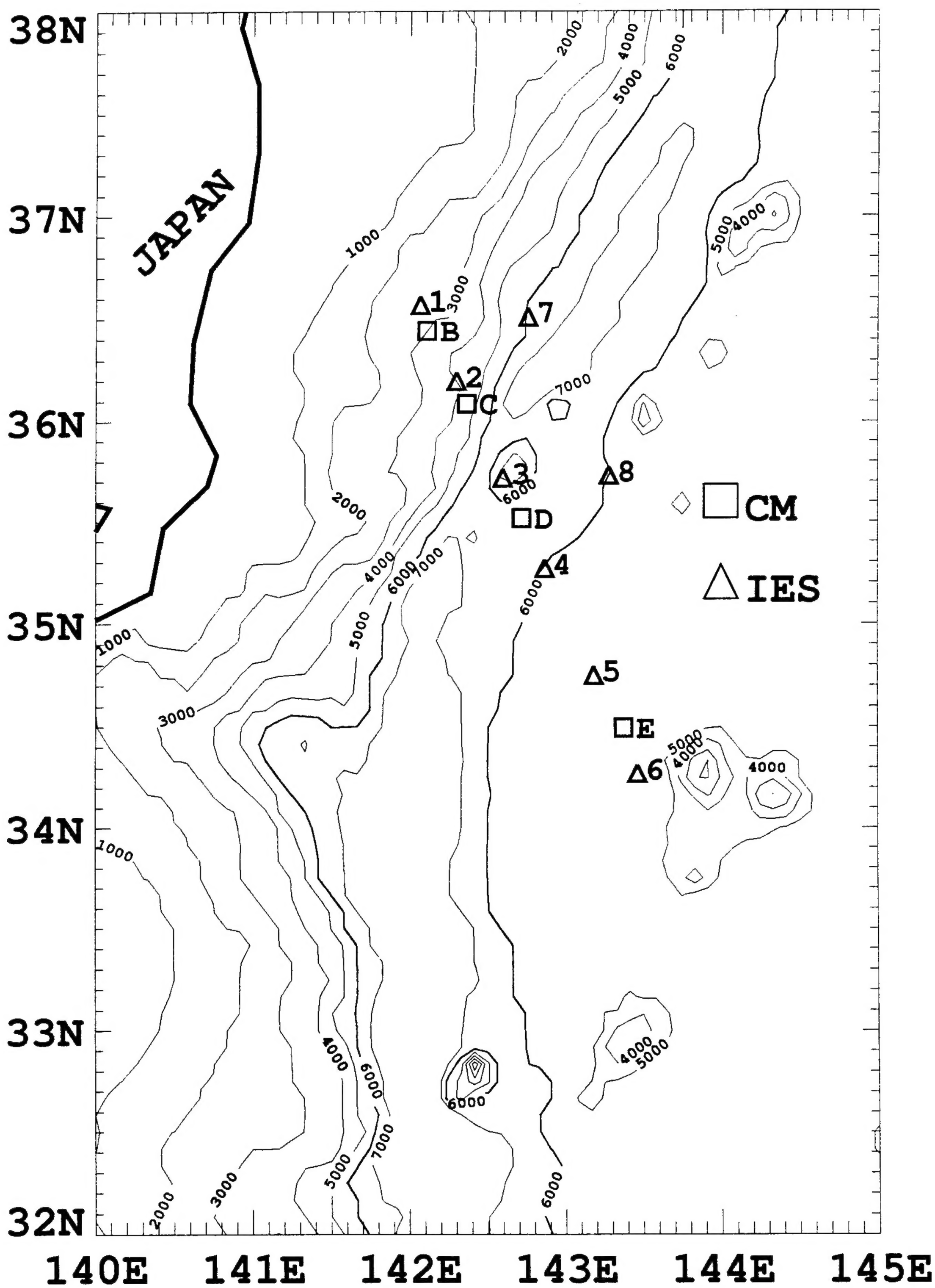
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37N
36N
35N
34N
33N
32N
140E
141E
142E
143E
144E
145E
JAPAN
CM
IES
1
2
3
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6
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8
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C
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6000
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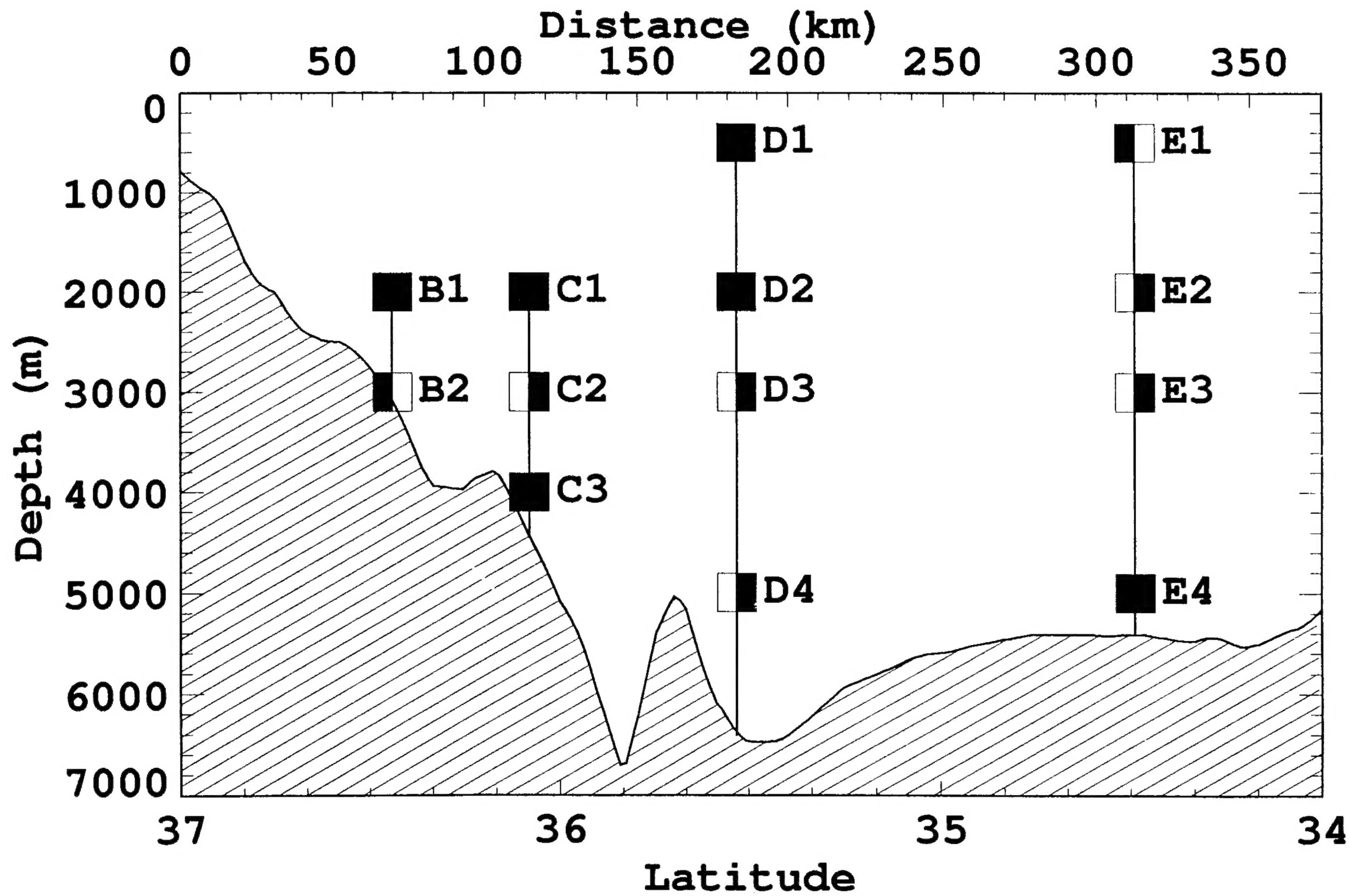
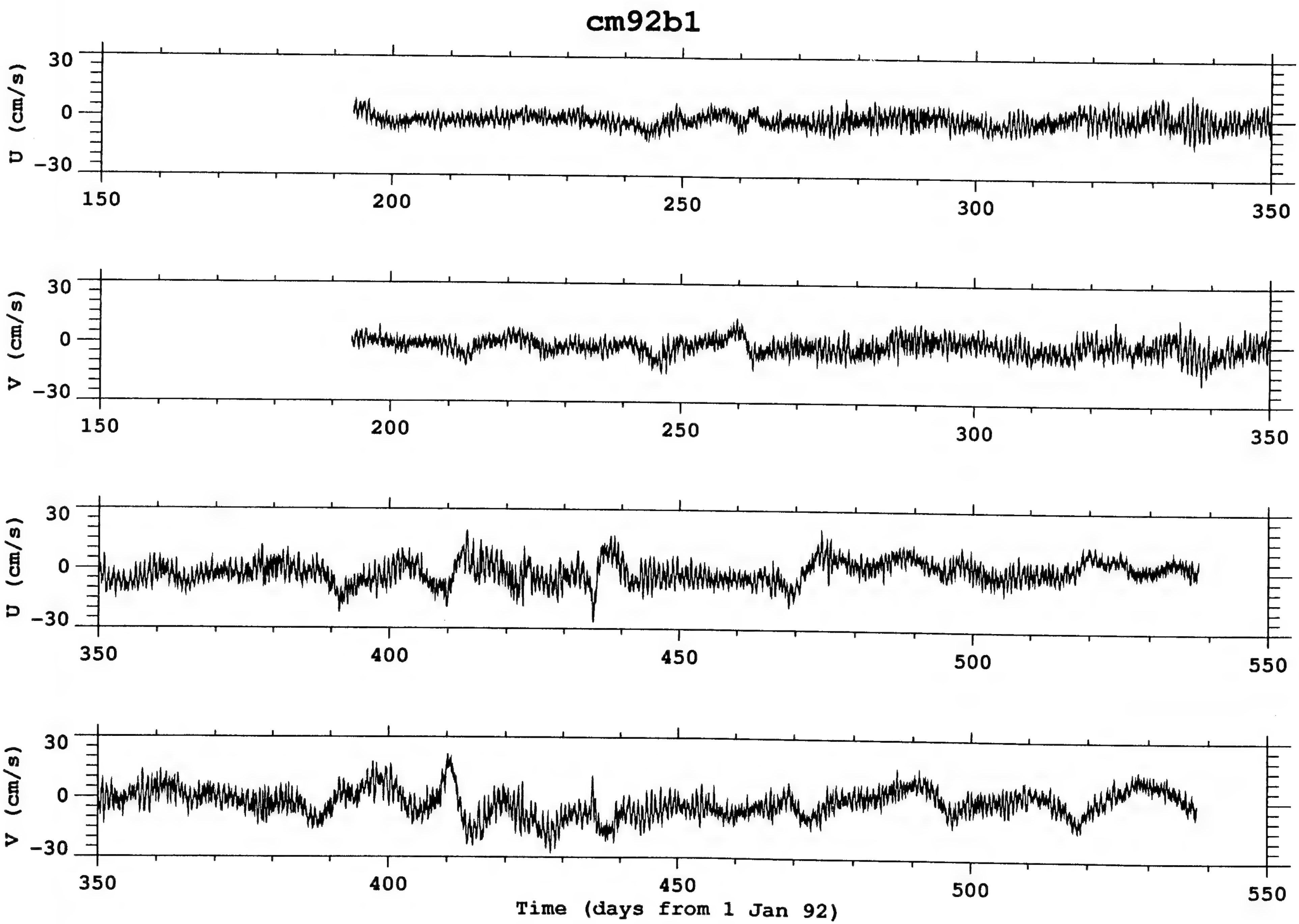


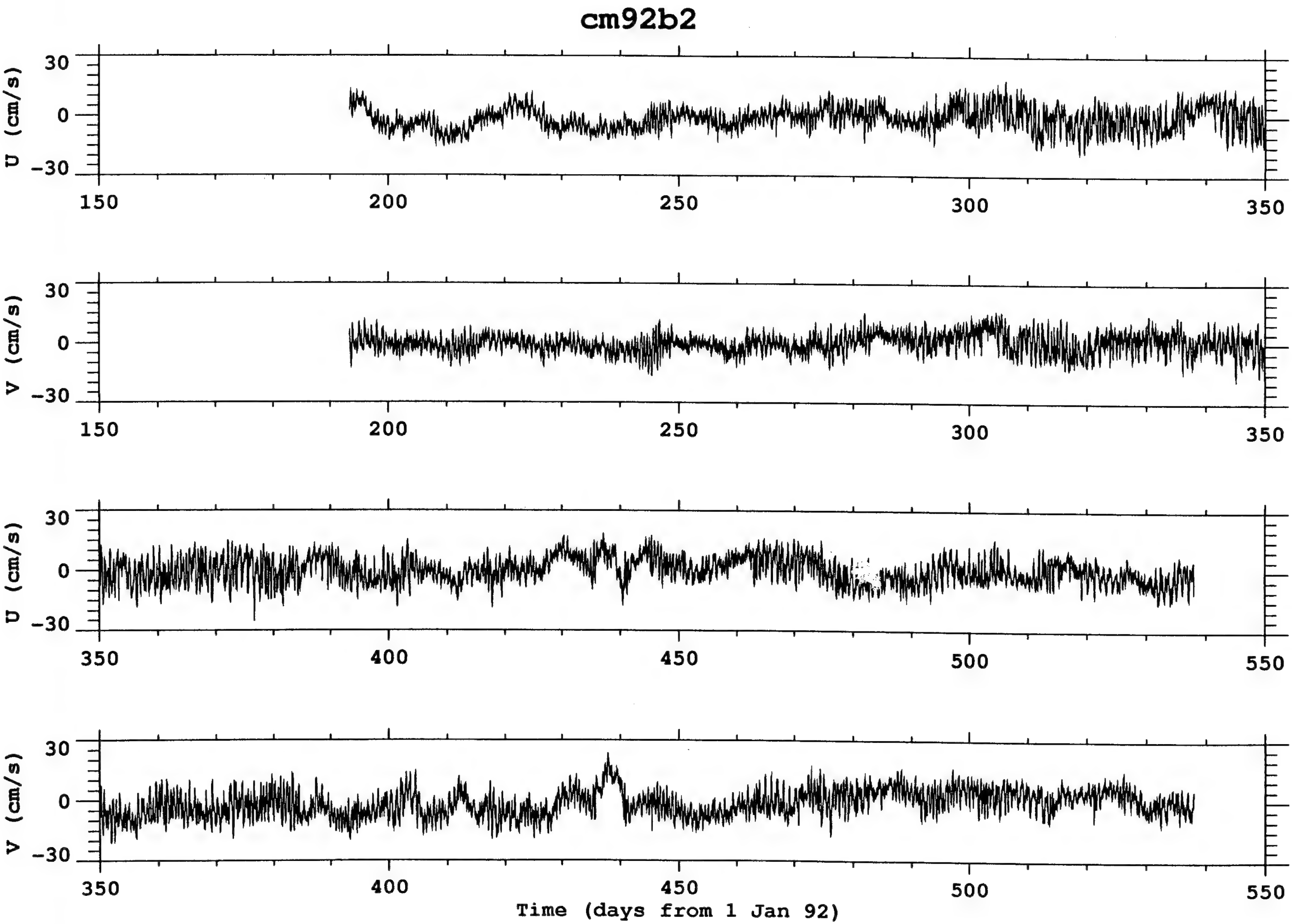
Distance (km)
0
50
100
150
200
250
300
350
Depth (m)
0
1000
2000
3000
4000
5000
6000
7000
B1
B2
C1
C2
C3
D1
D2
D3
D4
E1
E2
E3
E4
37
36
35
34
Latitude

Table 1: CURRENT METER SUMMARY							
Meter ID	Start Day	End Day	Lat ° N	Lon ° E	Meter Depth	Bottom Depth	Parameters
CM92B1	193.38	538.00	36.443	142.107	2046	3270	p,t,u,v
CM92B2	193.38	538.00	36.443	142.107	3046	3270	u,v
CM92C1	195.25	539.50	36.083	142.365	2172	4600	p,t,u,v
CM92C3	195.25	539.50	36.083	142.365	4172	4600	t,u,v
CM92D1	196.50	540.75	35.513	142.712	443	6380	p,t,u,v
CM92D2	196.50	540.75	35.513	142.712	1943	6380	u,v
CM92E1	199.25	543.75	34.493	143.378	525	5500	p,t,u,v
CM92E2	199.25	273.00	34.493	143.378	2025	5500	u,v
CM92E4	199.25	543.75	34.493	143.378	5025	5500	u,v
CM93B1	174.25	510.00	36.442	142.110	2017	3270	p,t,u,v
CM93C1	175.50	509.75	36.085	142.367	2156	4600	p,t,u,v
CM93C2	175.50	509.75	36.085	142.367	3156	4600	t,u,v
CM93C3	175.50	509.75	36.085	142.367	4156	4600	t,u,v
CM93D1	177.50	508.88	35.547	142.663	362	6380	p,t,u,v
CM93D2	177.50	508.88	35.547	142.663	1862	6380	t,u,v
CM93D3	177.50	508.88	35.547	142.663	2862	6380	t,u,v
CM93D4	177.50	508.88	35.547	142.663	4862	6380	t,u,v
CM93E1	180.25	285.00	34.493	143.378	530	5500	p,t,u,v
CM93E2	180.25	507.00	34.493	143.378	2030	5500	t,u,v
CM93E3	180.25	507.75	34.493	143.378	3030	5500	t,u,v
CM93E4	180.25	507.75	34.493	143.378	5030	5500	t,u,v

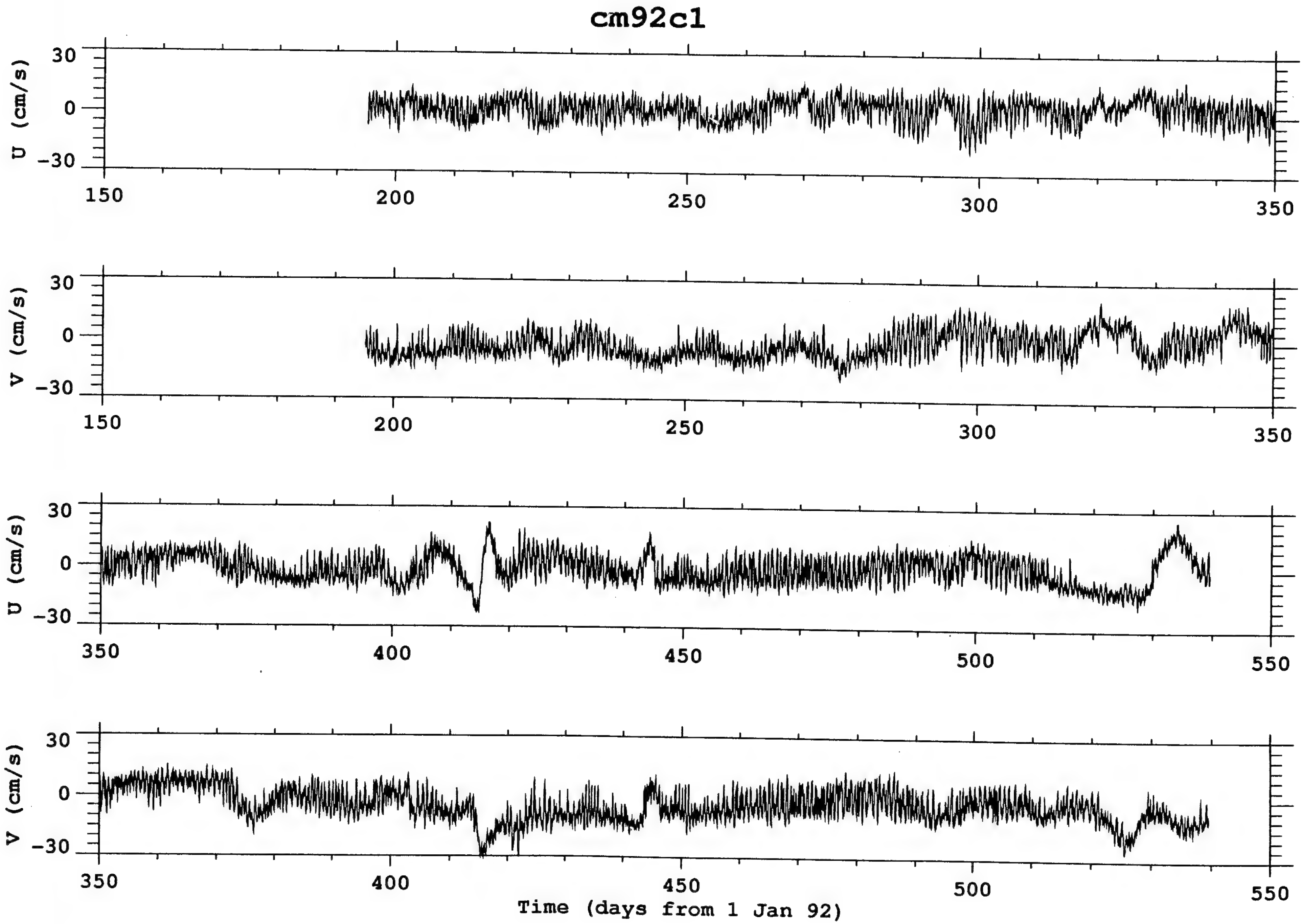
Table 2: CURRENT METER STATISTICS (uncorrected raw data)																		
Meter ID	U_{min}	U_{max}	$\overline{U}$	σ_U	V_{min}	V_{max}	$\overline{V}$	σ_V	$\overline{S}$	$\overline{\theta}$	T_{min}	T_{max}	$\overline{T}$	σ_T	P_{min}	P_{max}	$\overline{P}$	σ_P
CM92B1	-26.4	19.1	-1.0	5.0	-27.8	21.4	-1.6	5.9	1.9	212	1.78	2.13	1.88	0.05	2034	2073	2046	2.4
CM92B2	-25.3	18.6	-0.3	6.0	-21.0	23.5	-0.5	6.0	0.6	206			1.32*					
CM92C1	-22.8	25.1	1.1	6.7	-31.7	21.6	-2.9	7.5	3.1	160	1.66	1.96	1.80	0.04	2158	2228	2172	7.5
CM92C3	-20.9	22.6	-1.6	9.4	-30.4	22.6	-6.3	9.3	6.5	194	1.42	1.48	1.45	0.01				
CM92D1	-27.2	79.7	33.7	16.9	-42.8	77.0	10.2	15.4	35.2	73	4.15	17.17	10.27	3.03	408	776	443	38.3
CM92D2	-14.1	35.9	8.9	6.3	-21.6	27.5	3.6	6.9	9.6	68			2.39*					
CM92E1	-49.9	72.6	14.8	17.7	-62.2	58.7	-0.3	16.0	14.9	91	3.28	15.80	13.24	1.59	513	641	525	15.4
CM92E2	-10.3	11.6	1.0	3.5	-12.6	12.4	0.0	3.8	1.0	91			2.18*					
CM92E4	-17.5	24.8	3.7	7.3	-39.8	25.6	-2.0	10.9	4.2	119			1.52*					
CM93B1	-24.8	17.4	-0.6	4.4	-20.6	14.4	-1.3	4.8	1.4	204	1.80	2.01	1.88	0.03	2015	2031	2017	1.0
CM93C1	-13.8	17.4	-0.3	3.2	-15.9	12.6	-0.8	3.3	0.9	201	1.69	1.91	1.80	0.03	2141	2210	2156	6.4
CM93C2	-20.6	20.3	-4.0	9.1	-25.4	22.0	-3.3	9.9	5.2	230	1.48	1.56	1.52	0.01				
CM93C3	-9.4	19.4	0.8	2.9	-26.6	11.2	-3.2	4.4	3.3	166	1.42	1.48	1.45	0.01				
CM93D1	-49.9	93.1	27.3	25.8	-48.5	66.9	4.4	15.9	27.6	81	4.45	18.13	10.16	2.46	323	651	362	54
CM93D2	-17.2	31.3	5.9	6.5	-27.1	32.0	3.5	7.7	6.9	60	2.26	2.57	2.39	0.05				
CM93D3	-19.3	22.9	3.6	5.5	-16.1	23.3	7.3	6.1	8.2	26	1.61	1.78	1.67	0.02				
CM93D4	-20.0	19.2	-2.1	5.5	-7.2	13.7	2.4	3.2	3.2	318	1.49	1.53	1.51	0.01				
CM93E1	-51.9	69.2	25.1	21.3	-72.4	67.4	6.6	30.9	26.0	75	5.56	14.56	11.37	2.02	481	700	530	43
CM93E2	-13.1	29.2	3.6	4.8	-25.2	22.2	-1.0	5.5	3.7	105	2.04	2.39	2.18	0.06				
CM93E3	-12.1	21.2	2.9	4.2	-21.3	12.6	-1.5	5.3	3.3	117	1.59	1.71	1.65	0.02				
CM93E4	-14.5	27.8	2.4	5.7	-31.7	10.9	-7.6	5.7	8.0	162	1.51	1.54	1.52	0.01				

Table 3: CURRENT METER STATISTICS (offset-corrected raw data)																		
Meter ID	U_{min}	U_{max}	$\overline{U}$	σ_U	V_{min}	V_{max}	$\overline{V}$	σ_V	$\overline{S}$	$\overline{\theta}$	T_{min}	T_{max}	$\overline{T}$	σ_T	P_{min}	P_{max}	$\overline{P}$	σ_P
CM92B1	-23.1	16.4	-0.6	3.8	-24.6	18.7	-1.4	4.5	1.5	203	1.78	2.13	1.88	0.05	2034	2073	2046	2.4
CM92B2	-20.8	19.0	-1.2	5.5	-19.6	19.6	-0.4	4.6	1.3	250			1.32*					
CM92C1	-16.6	19.0	0.6	3.5	-25.1	16.8	-1.0	4.3	1.2	149	1.66	1.96	1.80	0.04	2158	2228	2172	7.5
CM92C3	-22.4	27.2	-0.2	4.4	-23.9	28.7	-2.0	4.4	2.0	185	1.42	1.48	1.45	0.01				
CM92D1	-26.2	73.6	28.8	16.4	-36.4	70.6	9.5	13.1	30.3	72	4.15	17.17	10.27	3.03	408	776	443	38.3
CM92D2	-17.3	27.1	1.8	5.6	-21.9	21.9	0.5	4.8	1.9	74			2.39*					
CM92E1	-44.8	67.0	12.7	15.5	-57.7	53.6	-1.2	13.6	12.7	95	3.28	15.80	13.24	1.59	513	641	525	15.4
CM92E2	-9.7	10.8	0.7	3.3	-13.3	11.1	-0.7	3.6	1.0	134			2.18*					
CM92E4	-18.5	17.1	0.0	3.8	-34.7	20.5	-4.2	7.1	4.2	180			1.52*					
CM93B1	-21.9	15.1	-0.5	2.9	-16.9	11.1	-0.7	3.1	0.9	214	1.80	2.01	1.88	0.03	2015	2031	2017	1.0
CM93C1	-13.8	17.7	-0.2	3.0	-16.4	12.1	-0.8	3.2	0.8	194	1.69	1.91	1.80	0.03	2141	2210	2156	6.4
CM93C2	-22.9	26.7	-1.5	4.1	-24.4	25.3	-1.4	4.5	2.0	226	1.48	1.56	1.52	0.01				
CM93C3	-8.1	17.2	0.1	2.4	-25.1	9.2	-2.6	3.7	2.6	177	1.42	1.48	1.45	0.01				
CM93D1	-48.7	92.7	26.8	25.4	-50.4	65.2	2.6	15.8	26.9	84	4.45	18.13	10.16	2.46	323	651	362	54
CM93D2	-18.2	31.9	6.1	6.7	-25.5	33.7	4.6	7.9	7.6	53	2.26	2.57	2.39	0.05				
CM93D3	-17.0	20.2	3.1	4.3	-13.3	19.0	4.2	4.5	5.2	37	1.61	1.78	1.67	0.02				
CM93D4	-23.2	22.3	-0.2	5.9	-10.2	14.3	.4	3.4	2.4	356	1.49	1.53	1.51	0.01				
CM93E1	-44.1	66.6	21.7	18.2	-66.5	59.7	5.8	26.0	22.5	75	5.56	14.56	11.37	2.02	481	700	530	43
CM93E2	-14.7	30.0	2.3	5.0	-24.6	19.8	-2.5	5.2	3.4	137	2.04	2.39	2.18	0.06				
CM93E3	-15.9	23.0	2.0	4.9	-24.0	10.0	-4.0	4.9	4.5	153	1.59	1.71	1.65	0.02				
CM93E4	-10.5	26.4	2.8	5.0	-27.5	14.9	-4.6	6.0	5.4	149	1.51	1.54	1.52	0.01				


cm92b1
U (cm/s)
30
0
−30
150
200
250
300
350
V (cm/s)
30
0
−30
150
200
250
300
350
U (cm/s)
30
0
−30
350
400
450
500
550
V (cm/s)
30
0
−30
350
400
450
500
550
Time (days from 1 Jan 92)



cm92b2
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)



cm92c1
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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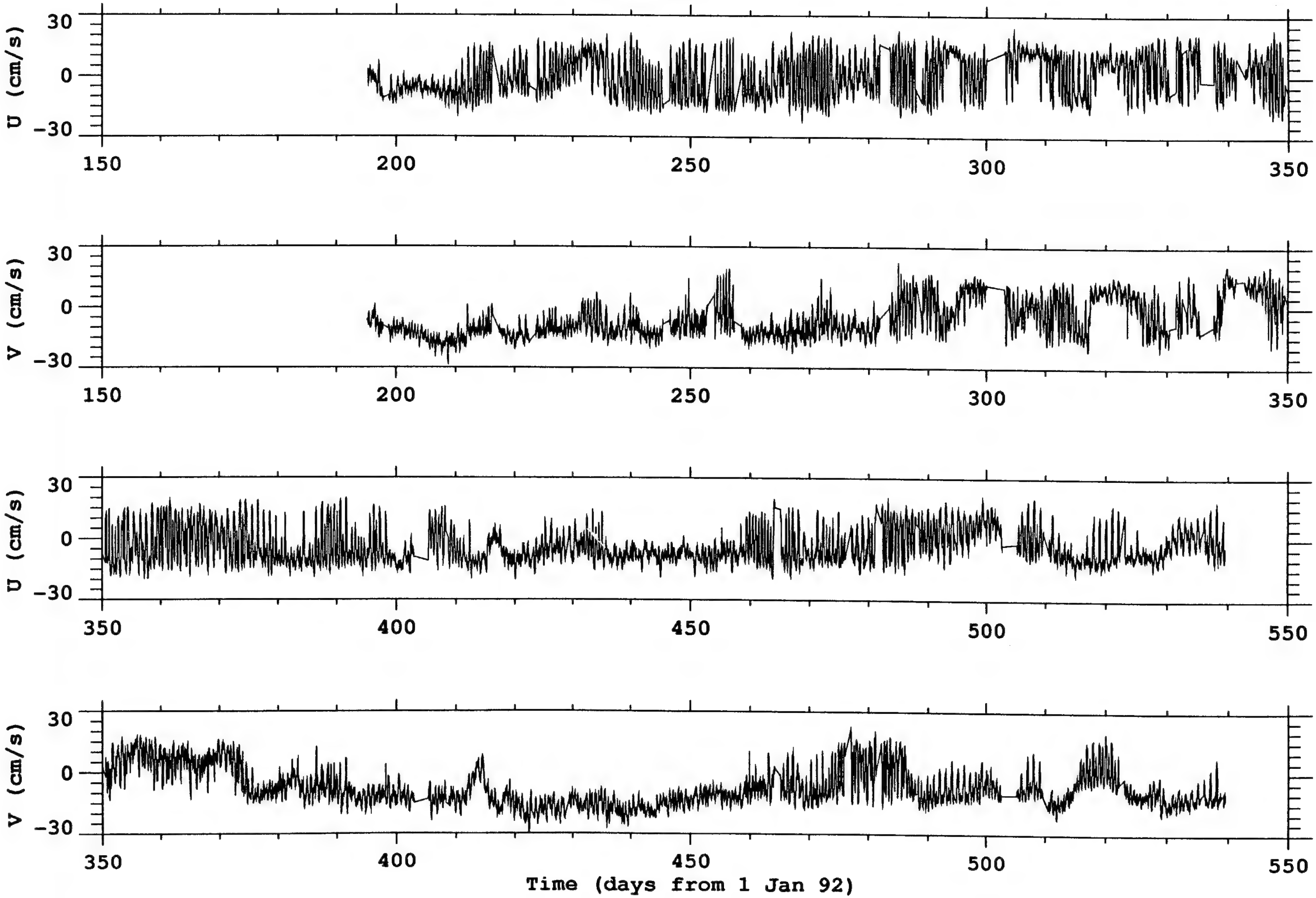
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92c3


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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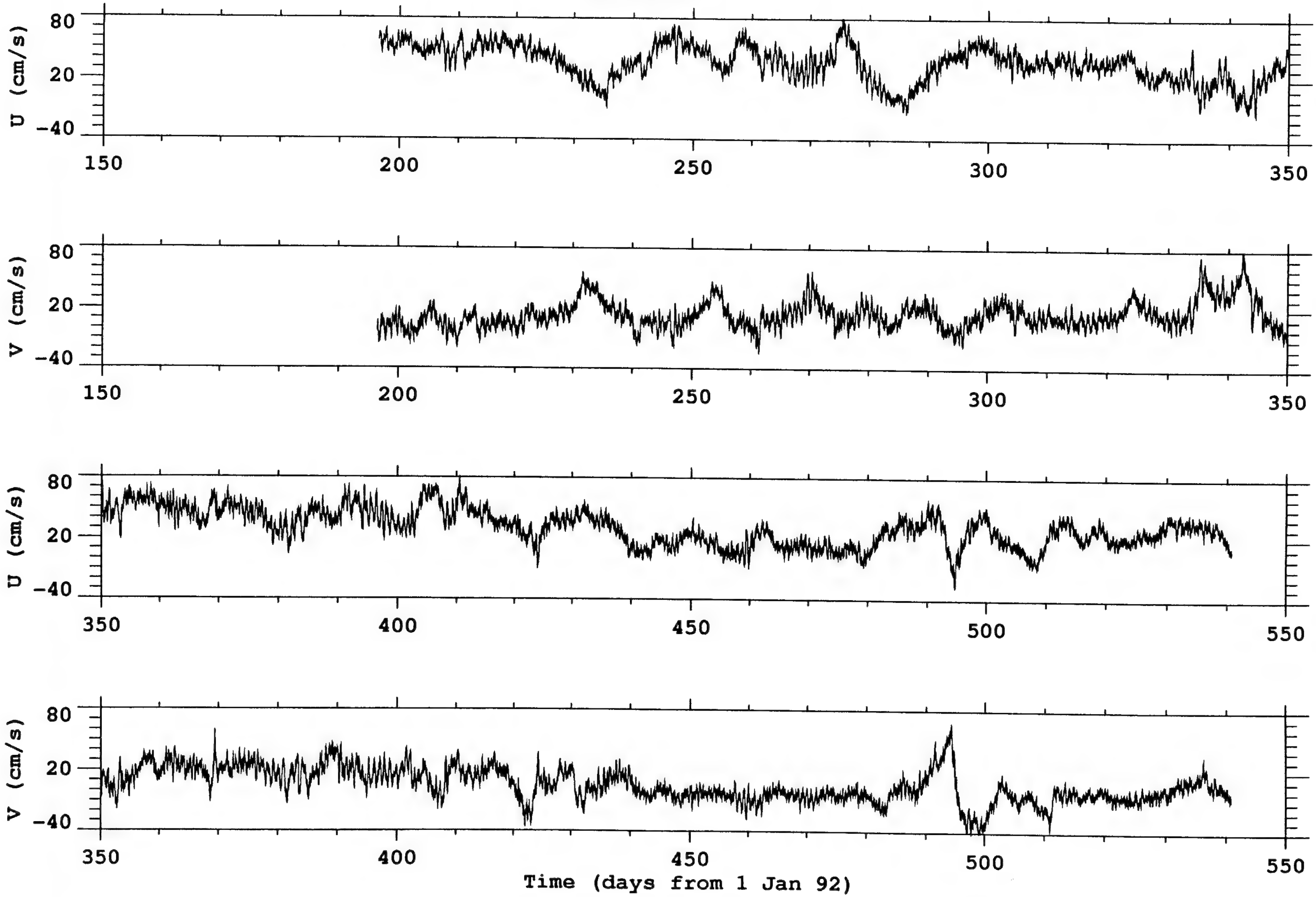
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92d1


U (cm/s)
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200
250
300
350
V (cm/s)
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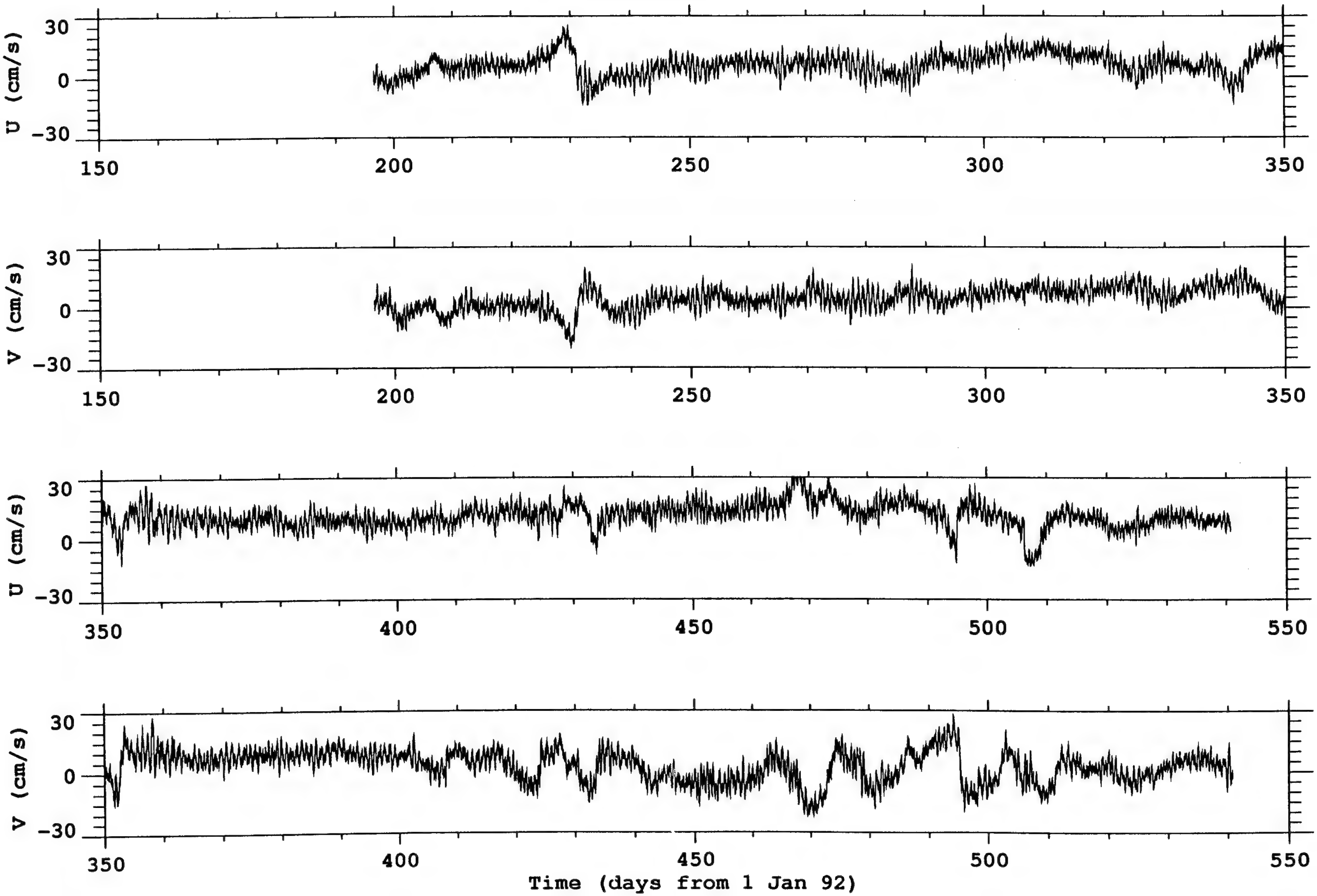
20
-40
150
200
250
300
350
U (cm/s)
80
20
-40
350
400
450
500
550
V (cm/s)
80
20
-40
350
400
450
500
550
Time (days from 1 Jan 92)

cm92d2



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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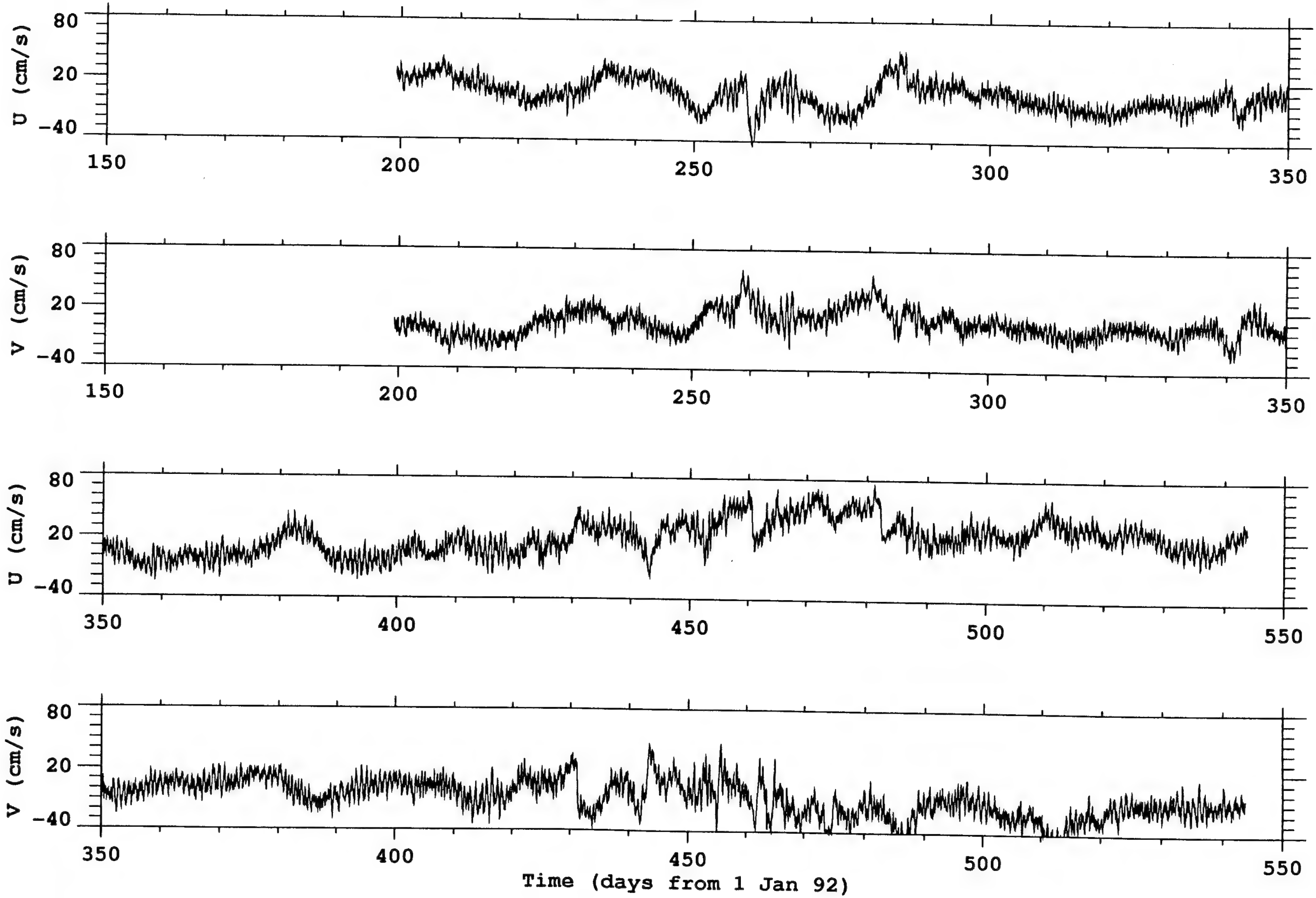
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92e1



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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20
-40
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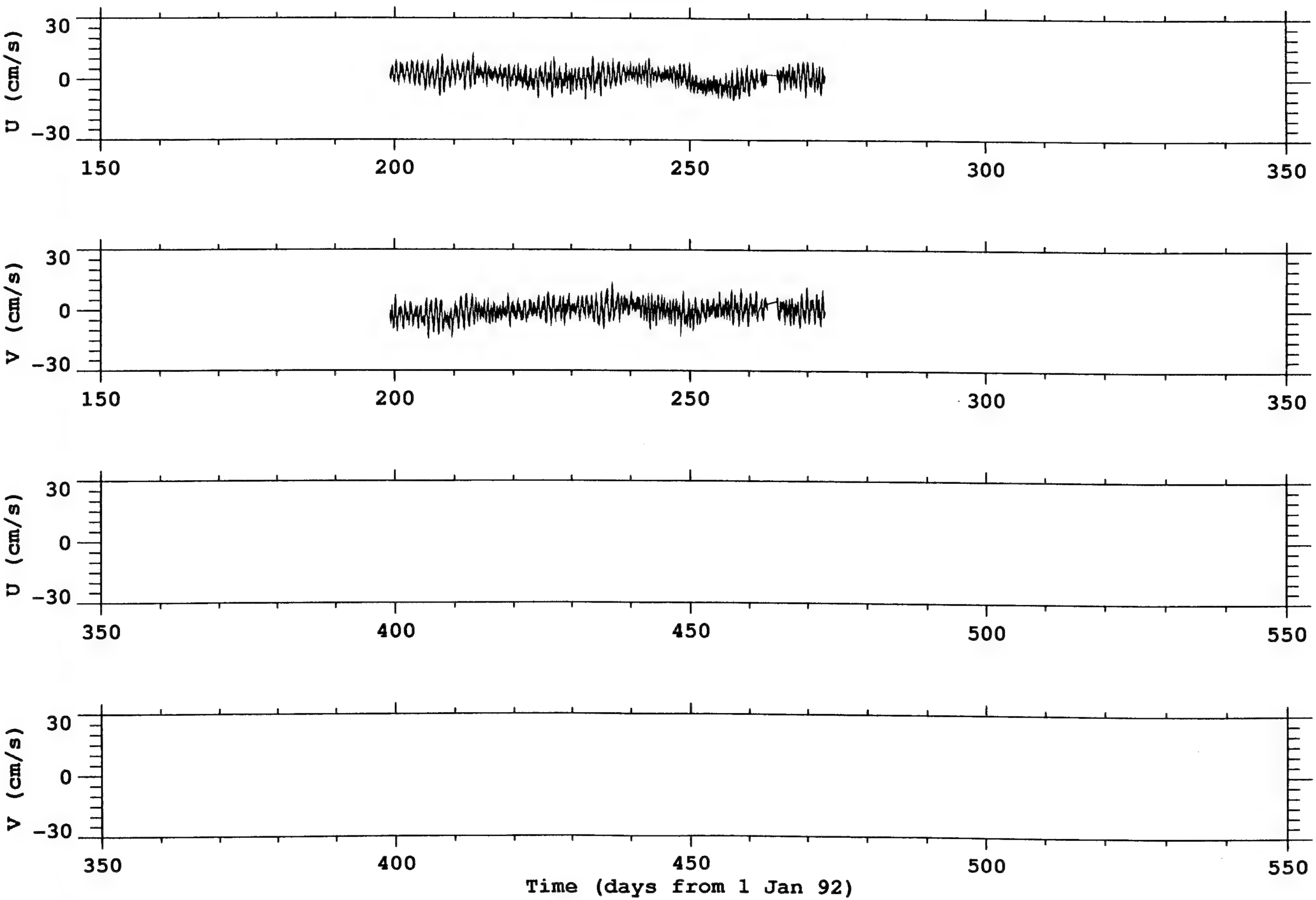
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92e2



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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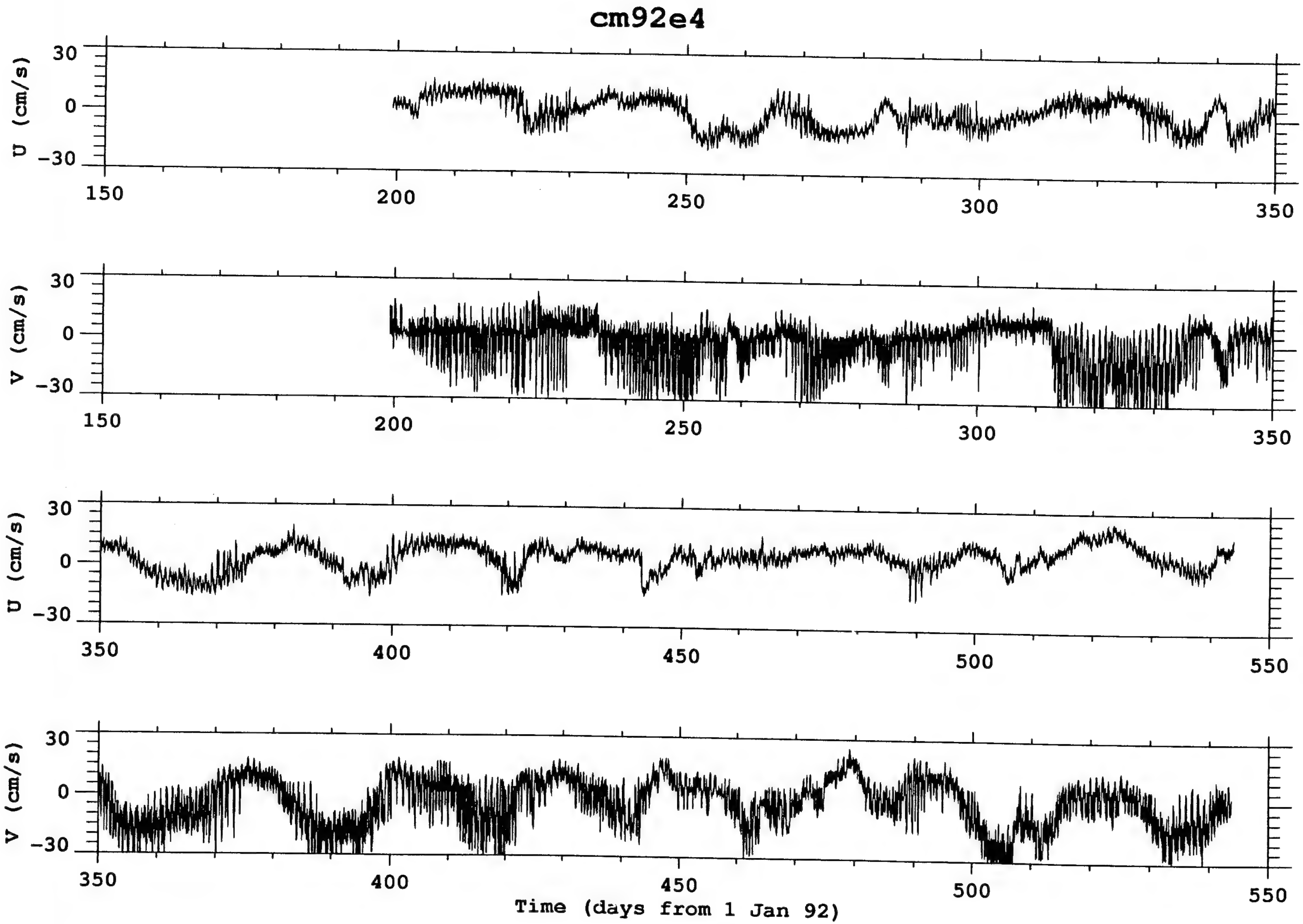
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)


cm92e4
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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−30
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200
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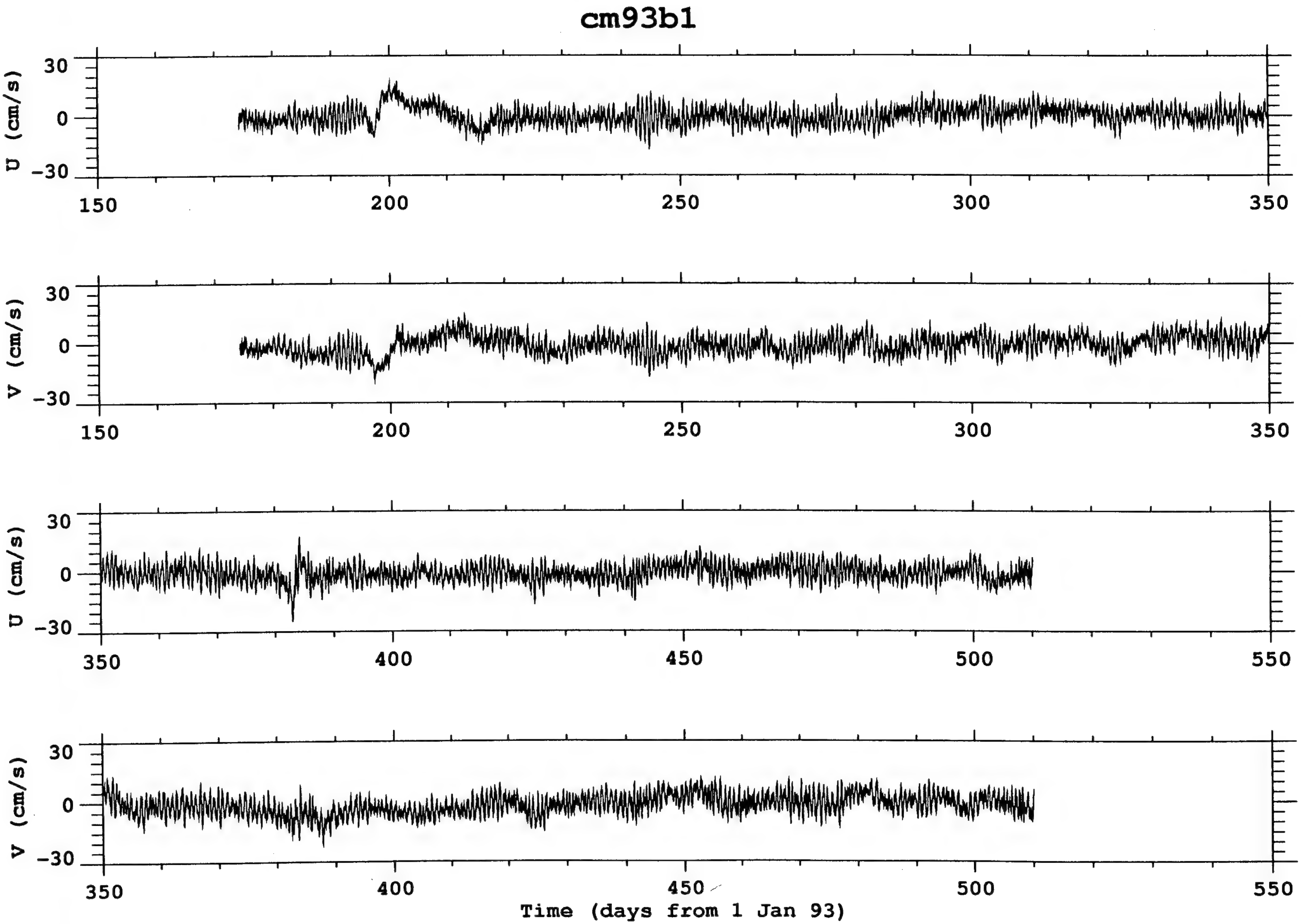
350
400
450
500
550
Time (days from 1 Jan 92)


cm93b1
U (cm/s)
V (cm/s)
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0
-30
150
200
250
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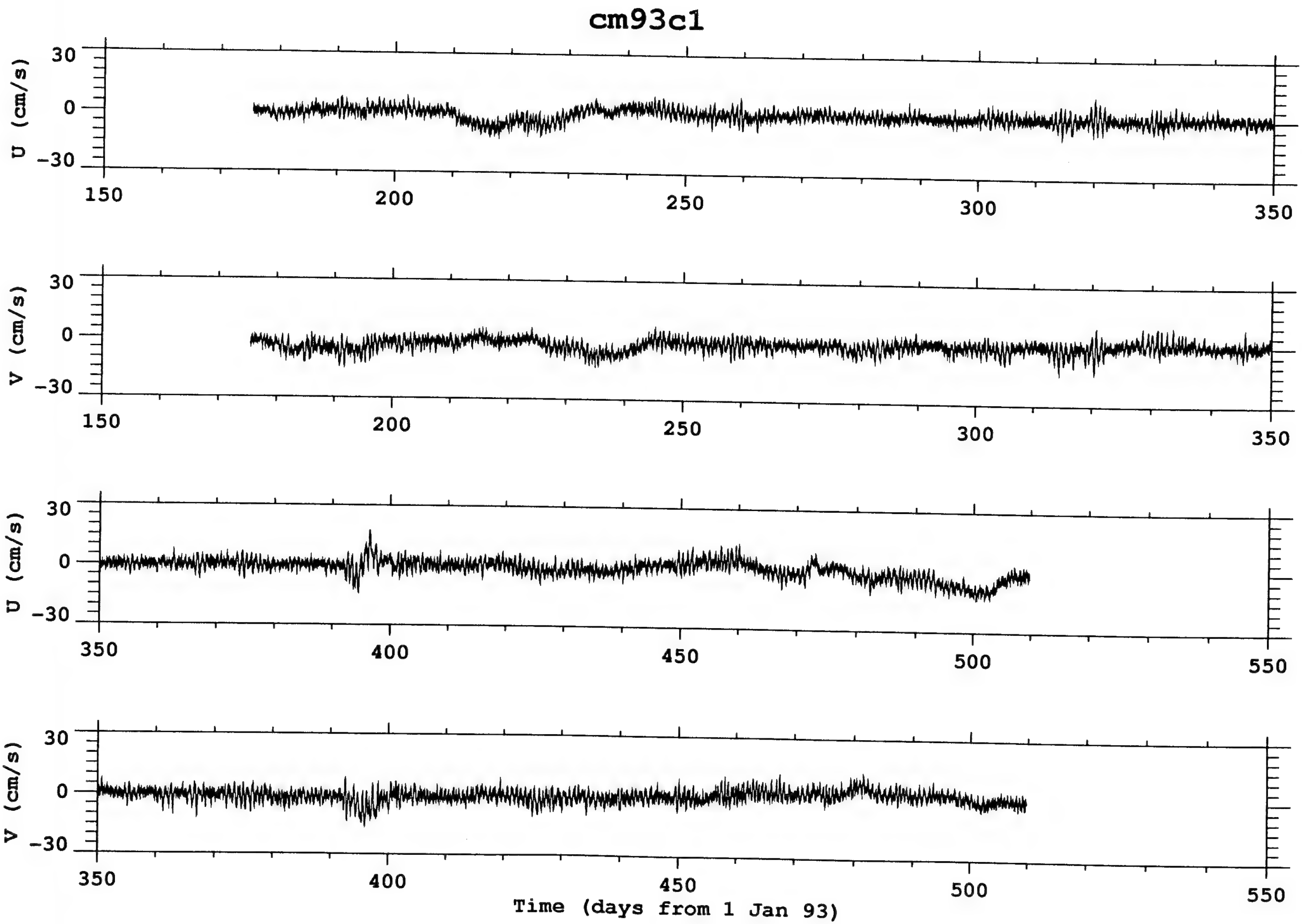
350
400
450
500
550
Time (days from 1 Jan 93)


cm93c1
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V (cm/s)
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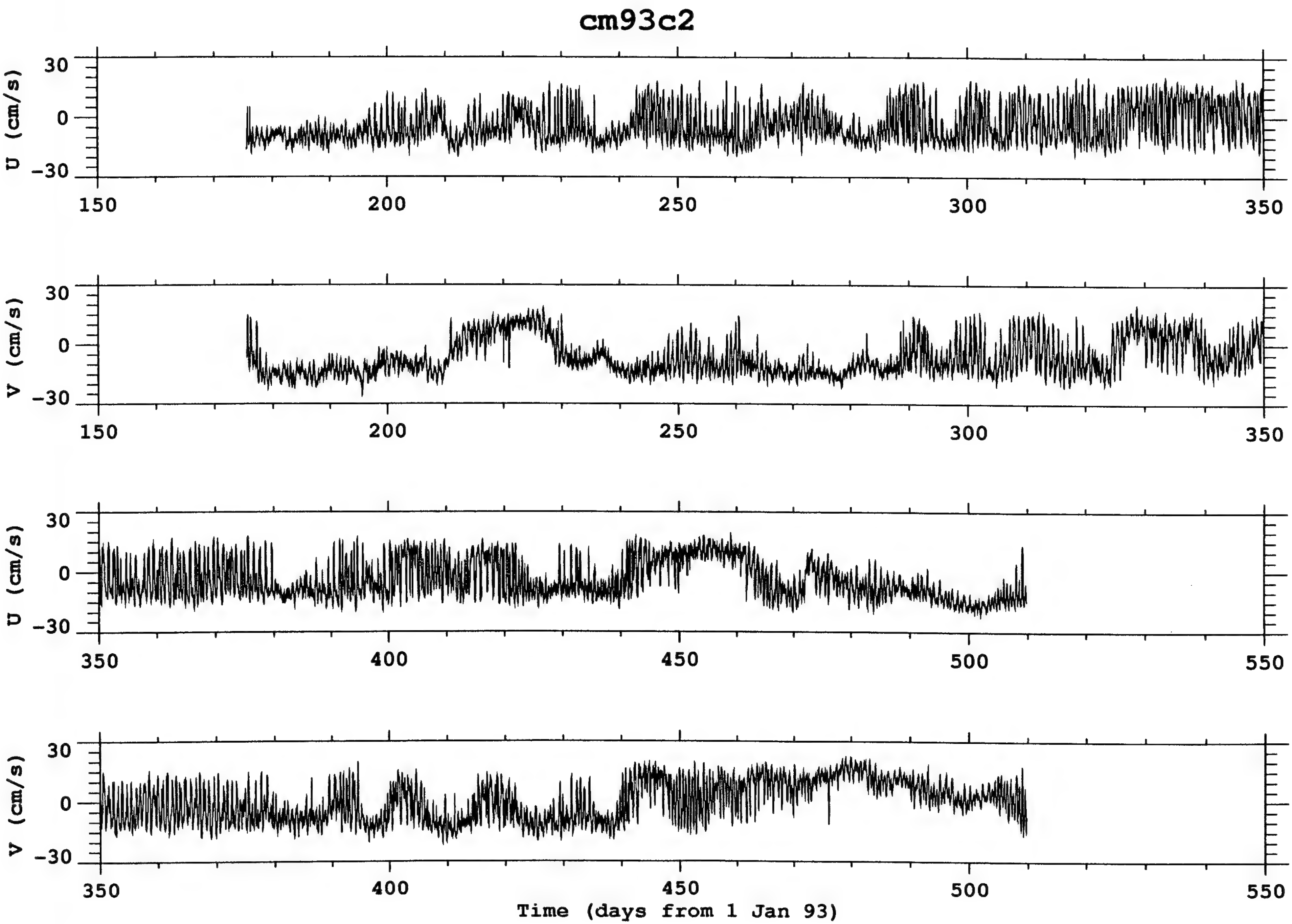
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)


cm93c2
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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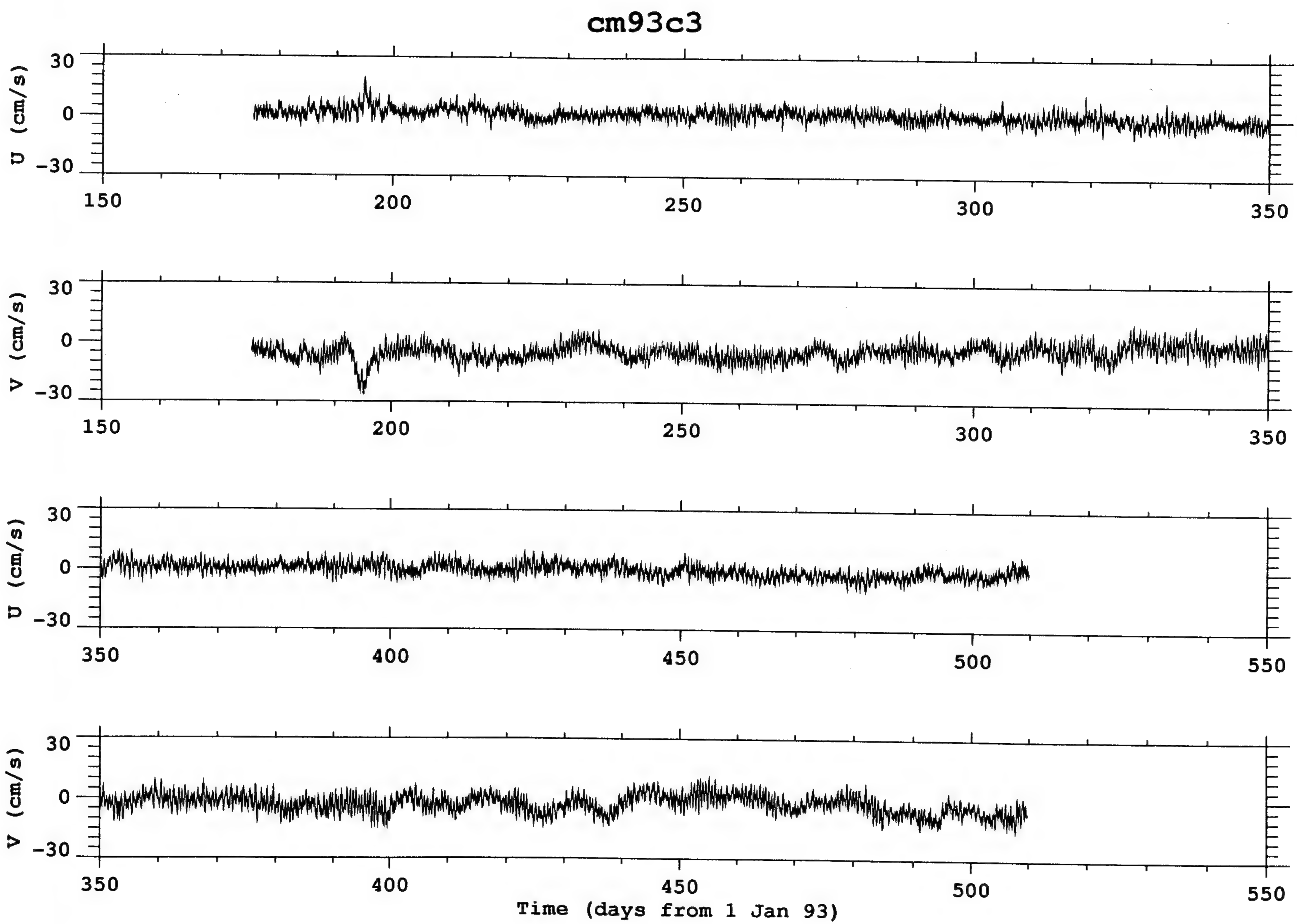
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)



cm93c3
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V (cm/s)
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−30
150
200
250
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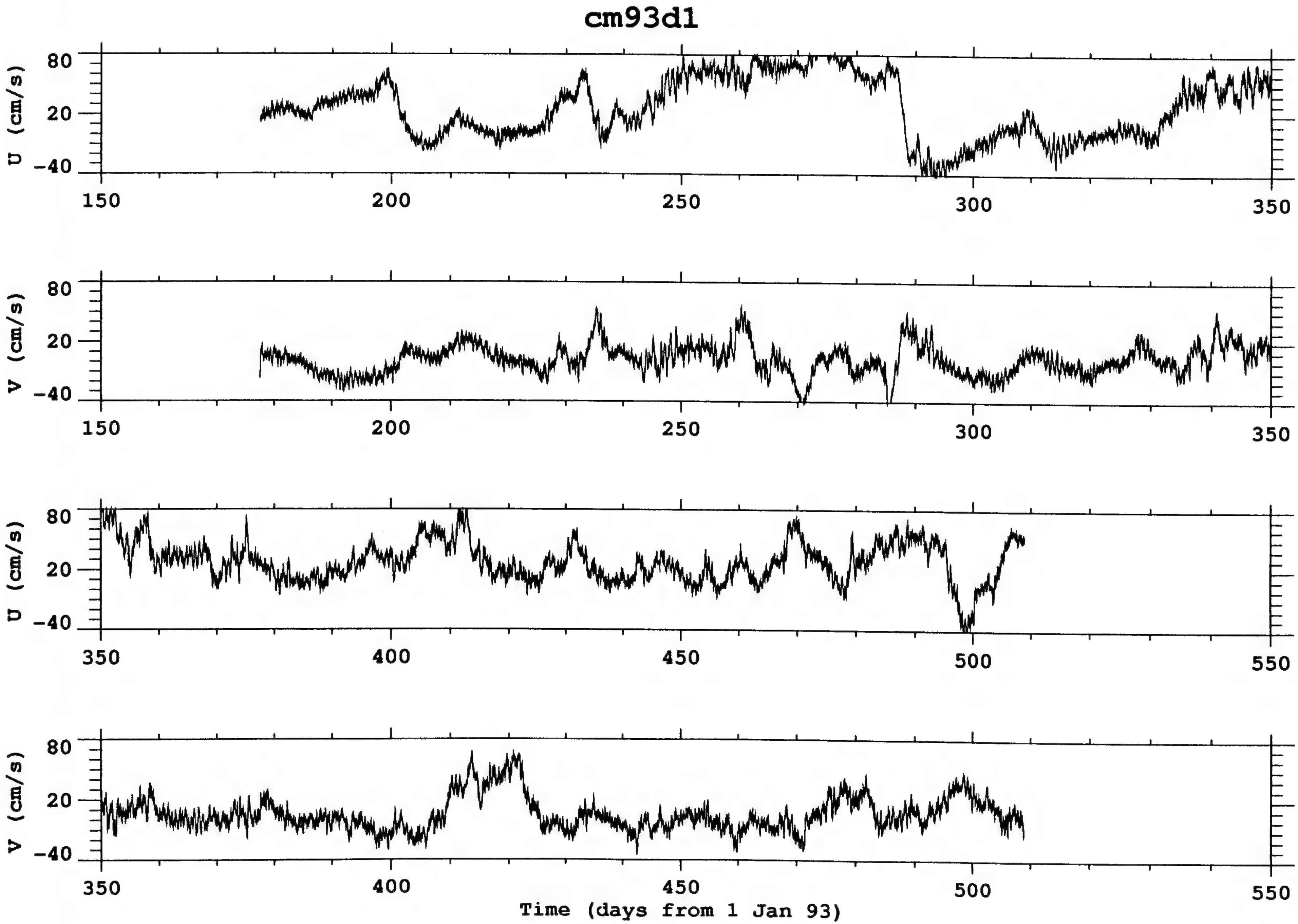
350
400
450
500
550
Time (days from 1 Jan 93)


cm93d1
U (cm/s)
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20
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150
200
250
300
350
V (cm/s)
80
20
-40
150
200
250
300
350
U (cm/s)
80
20
-40
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400
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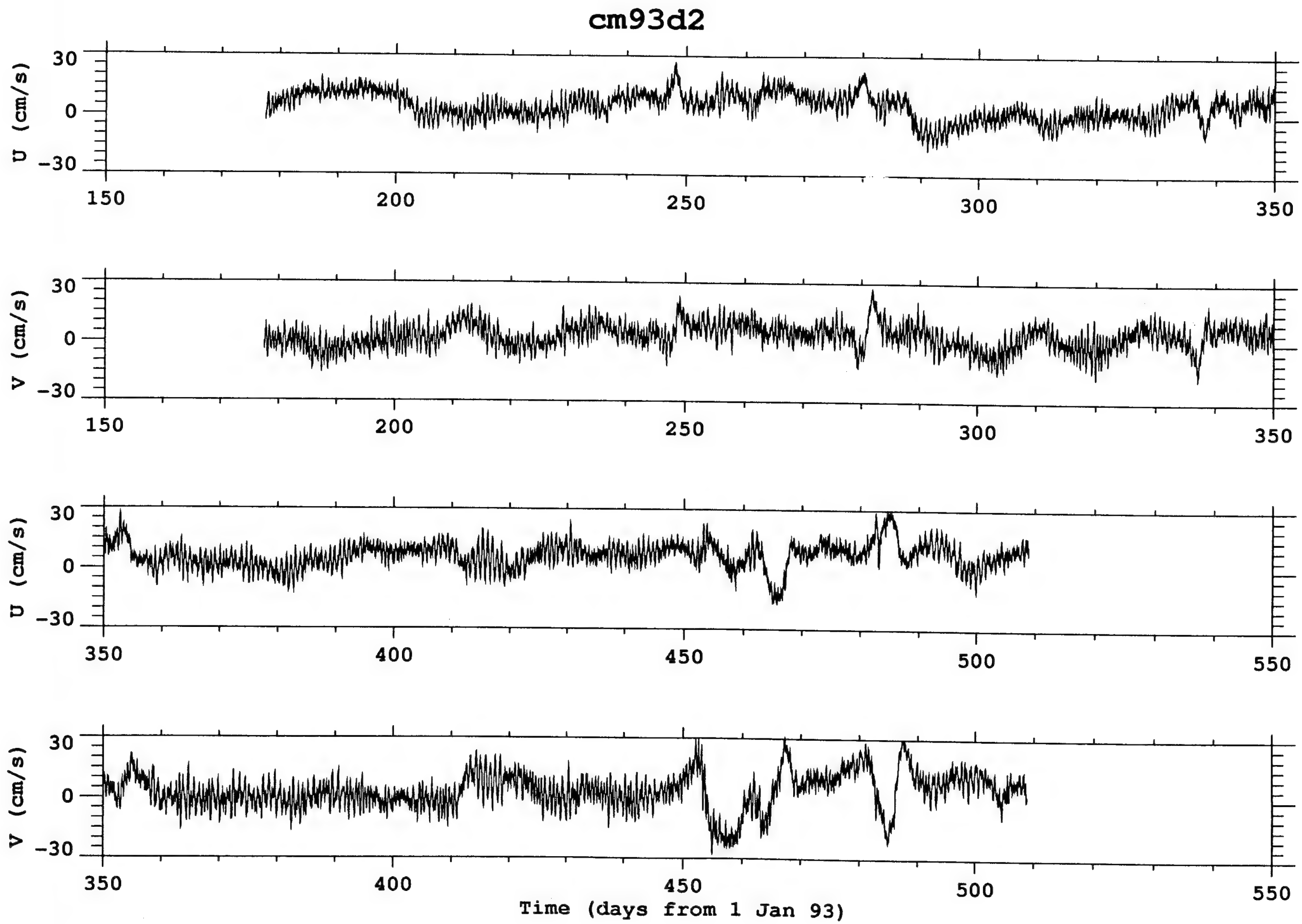
500
550
V (cm/s)
80
20
-40
350
400
450
500
550
Time (days from 1 Jan 93)



cm93d2
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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0
−30
150
200
250
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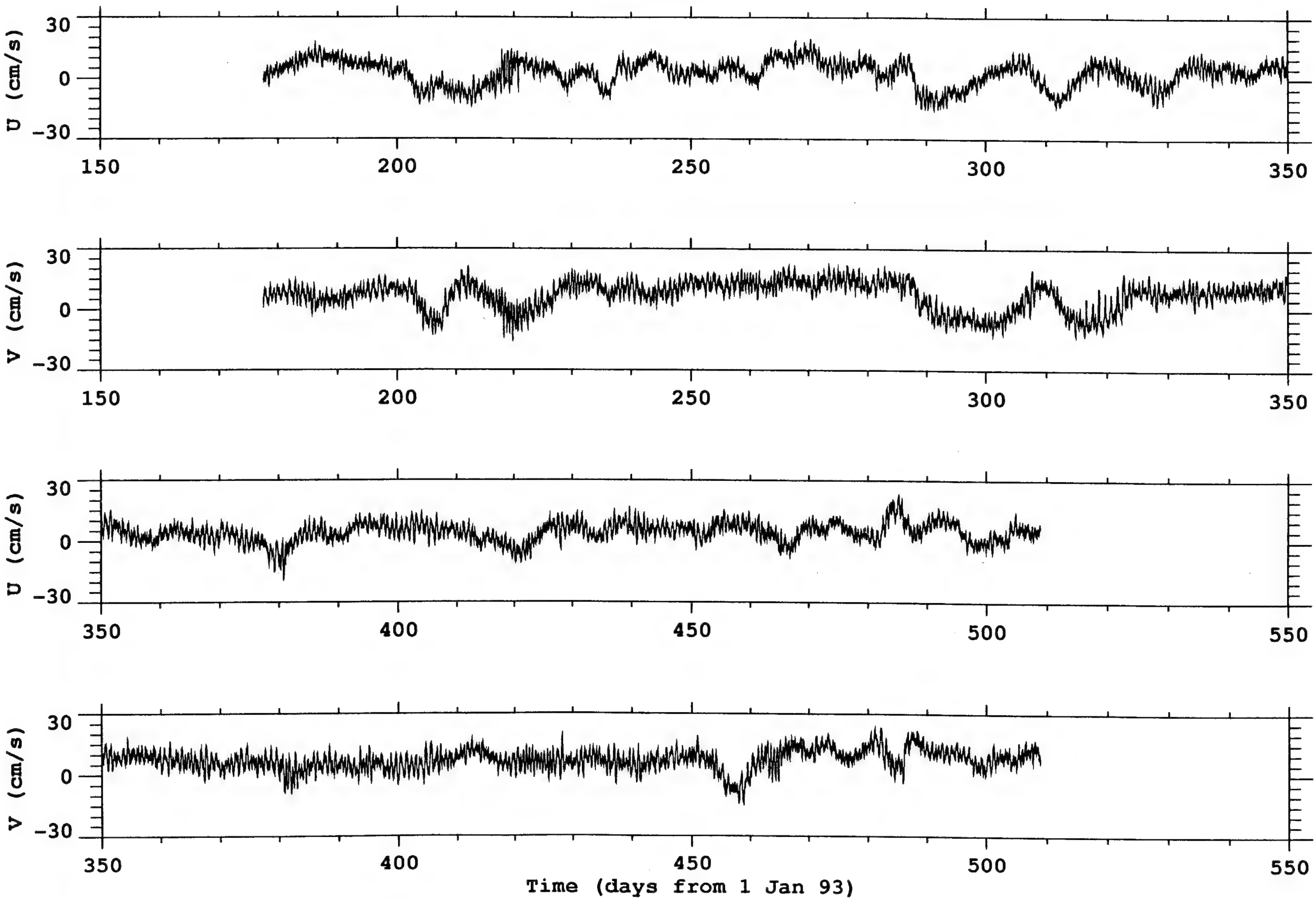
350
400
450
500
550
Time (days from 1 Jan 93)

cm93d3



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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-30
150
200
250
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350
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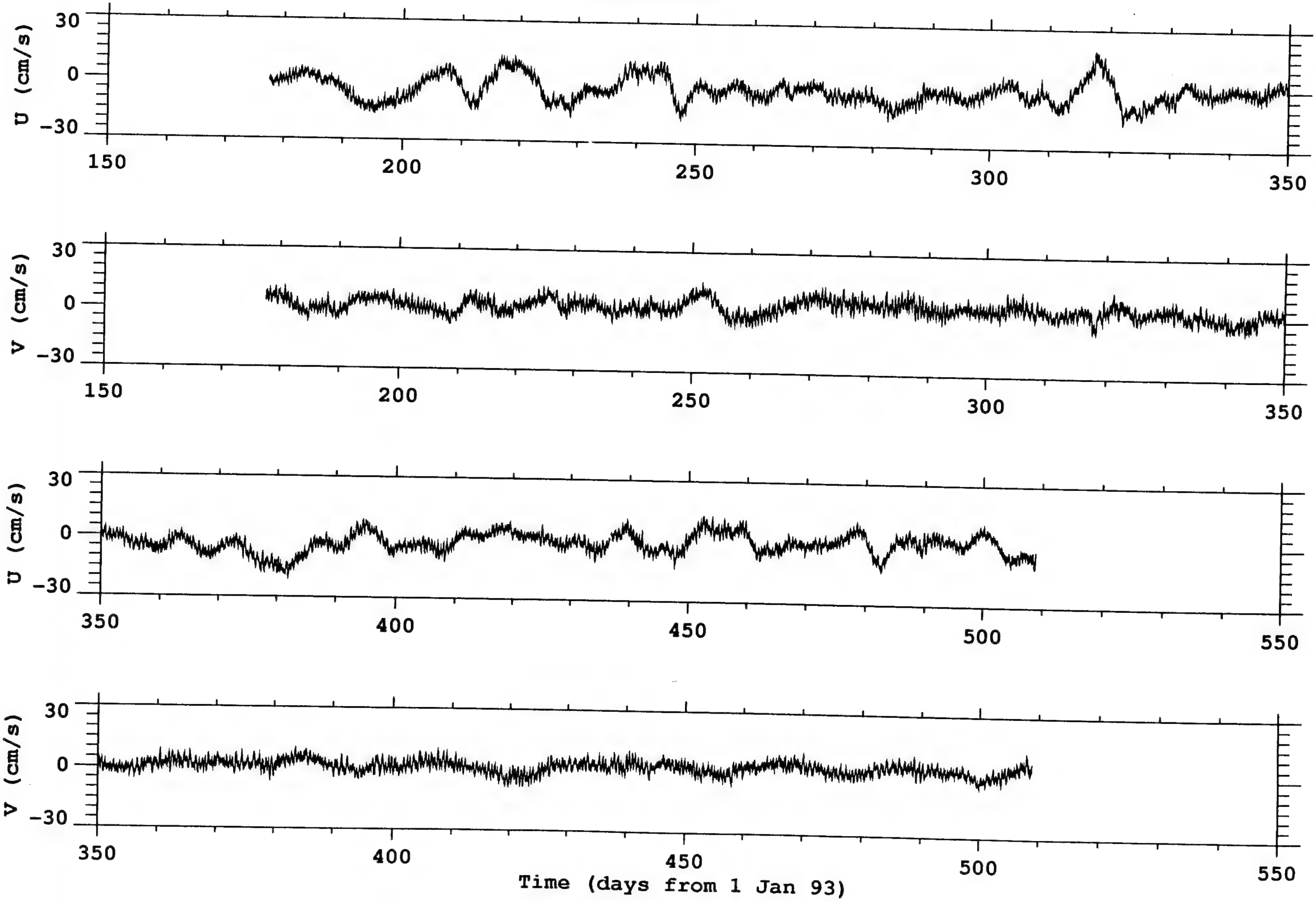
450
500
550
Time (days from 1 Jan 93)

cm93d4



U (cm/s)
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350
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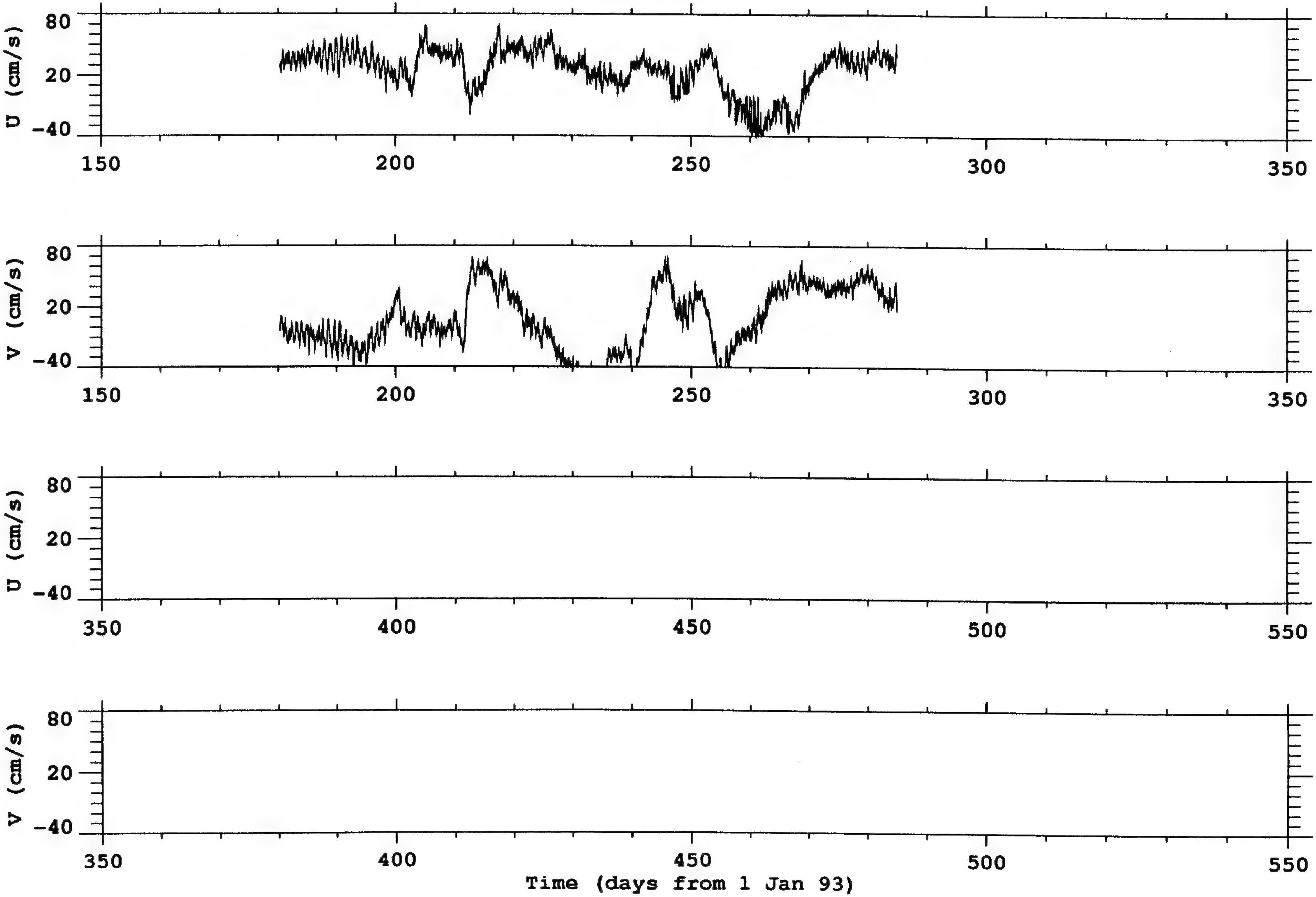
450
500
550
Time (days from 1 Jan 93)

cm93e1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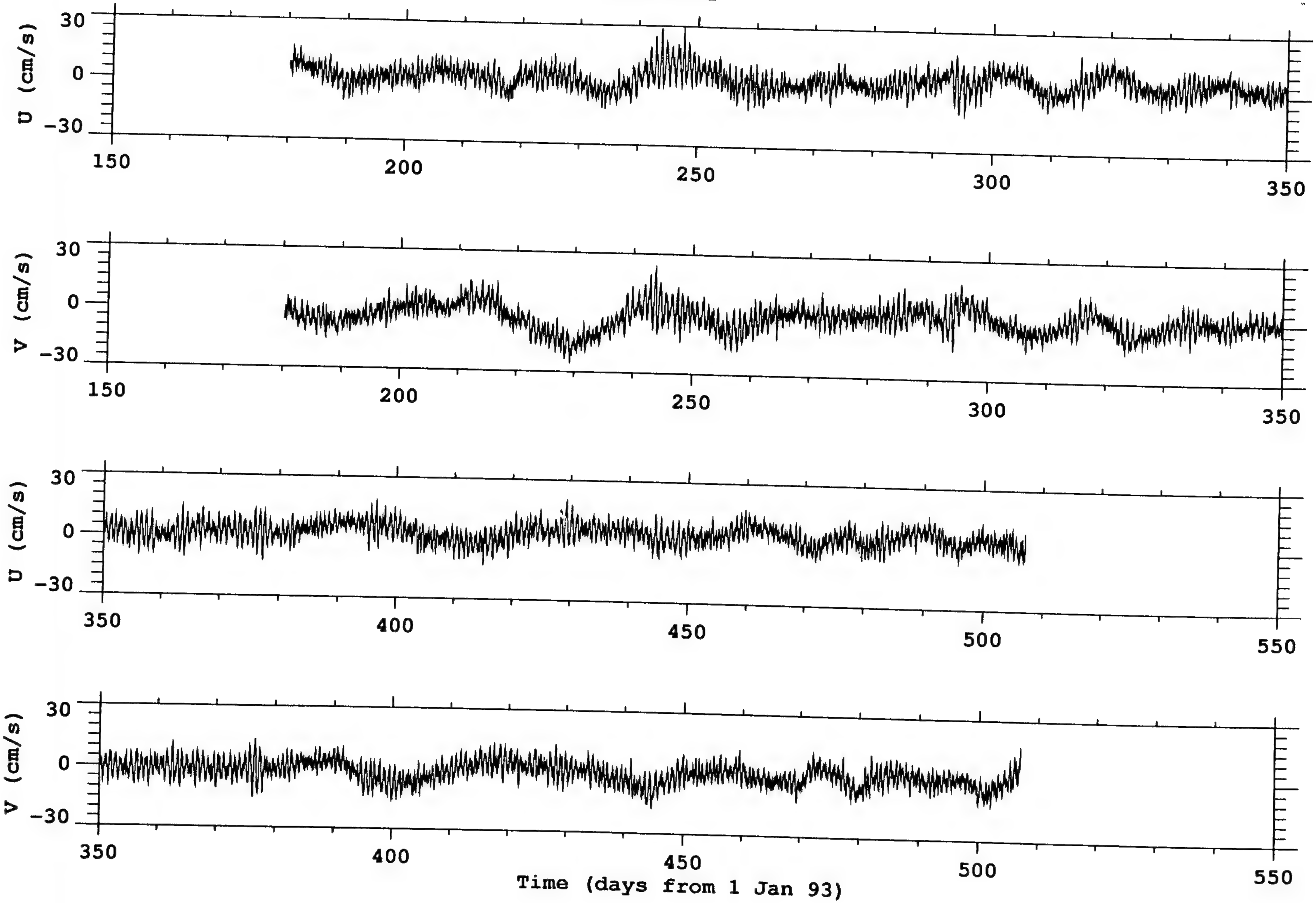
Time (days from 1 Jan 93)

cm93e2



U (cm/s)
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V (cm/s)
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−30
150
200
250
300
350
U (cm/s)
30
0
−30
350
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V (cm/s)
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−30
350
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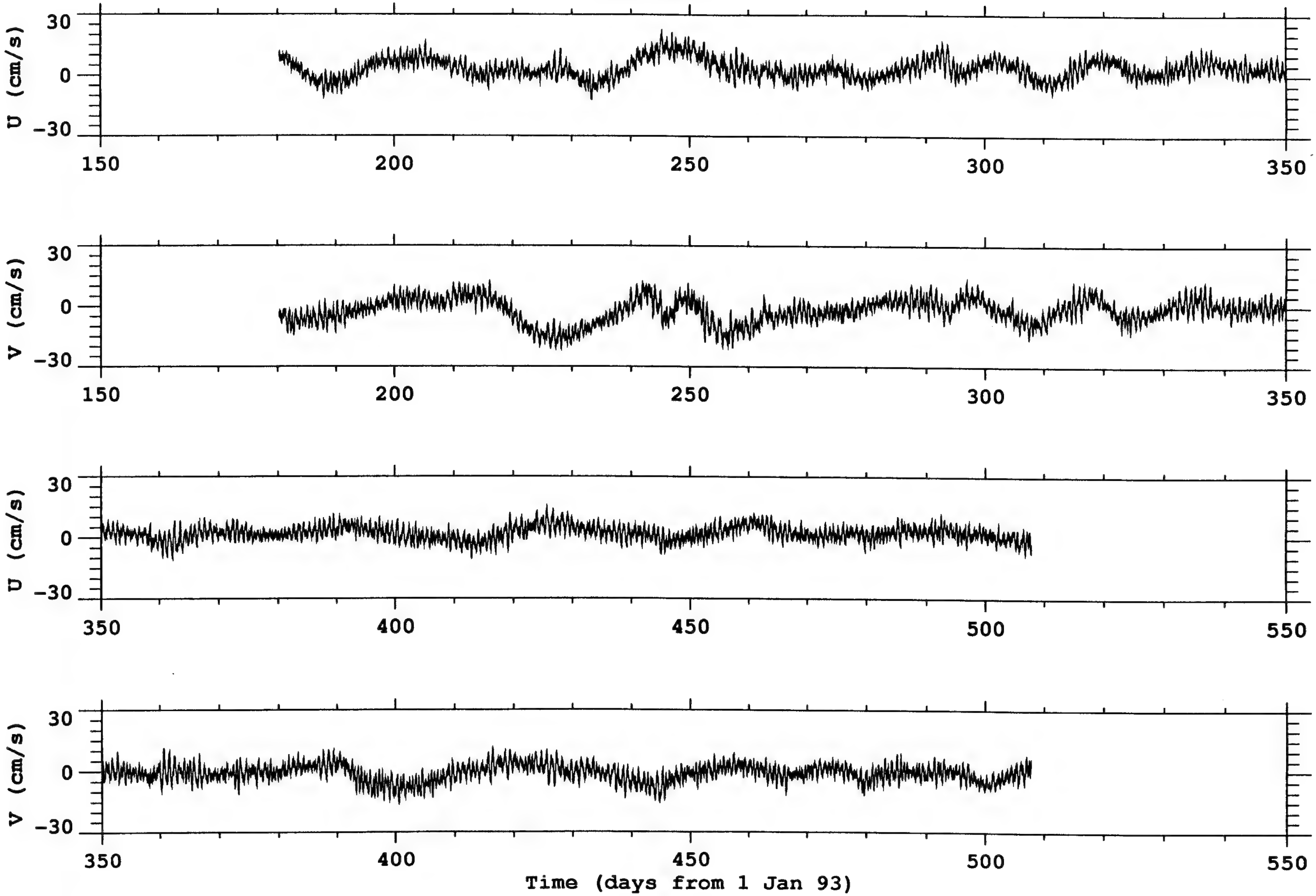
500
550
Time (days from 1 Jan 93)

cm93e3



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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-30
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350
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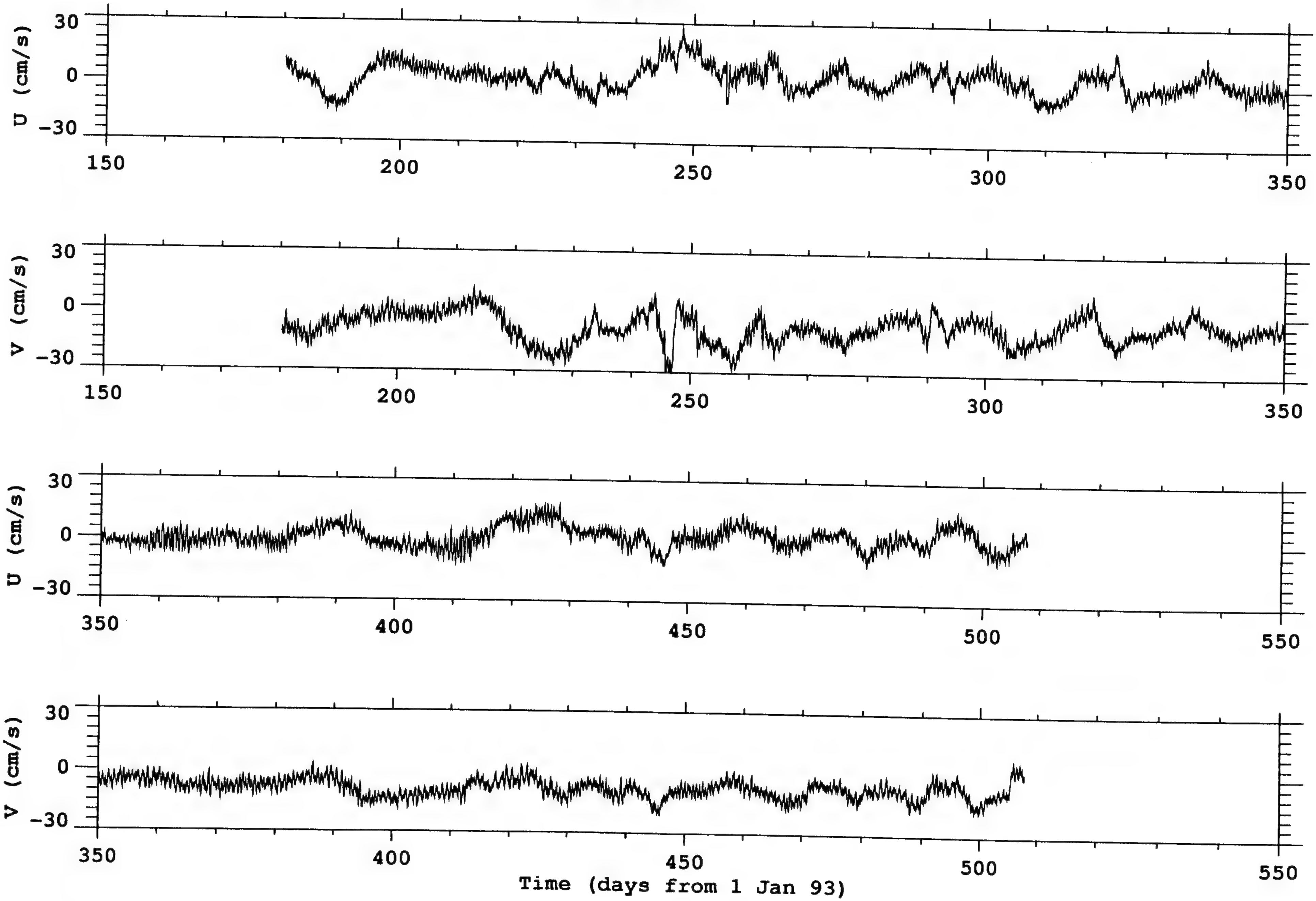
550
Time (days from 1 Jan 93)

cm93e4


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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-30
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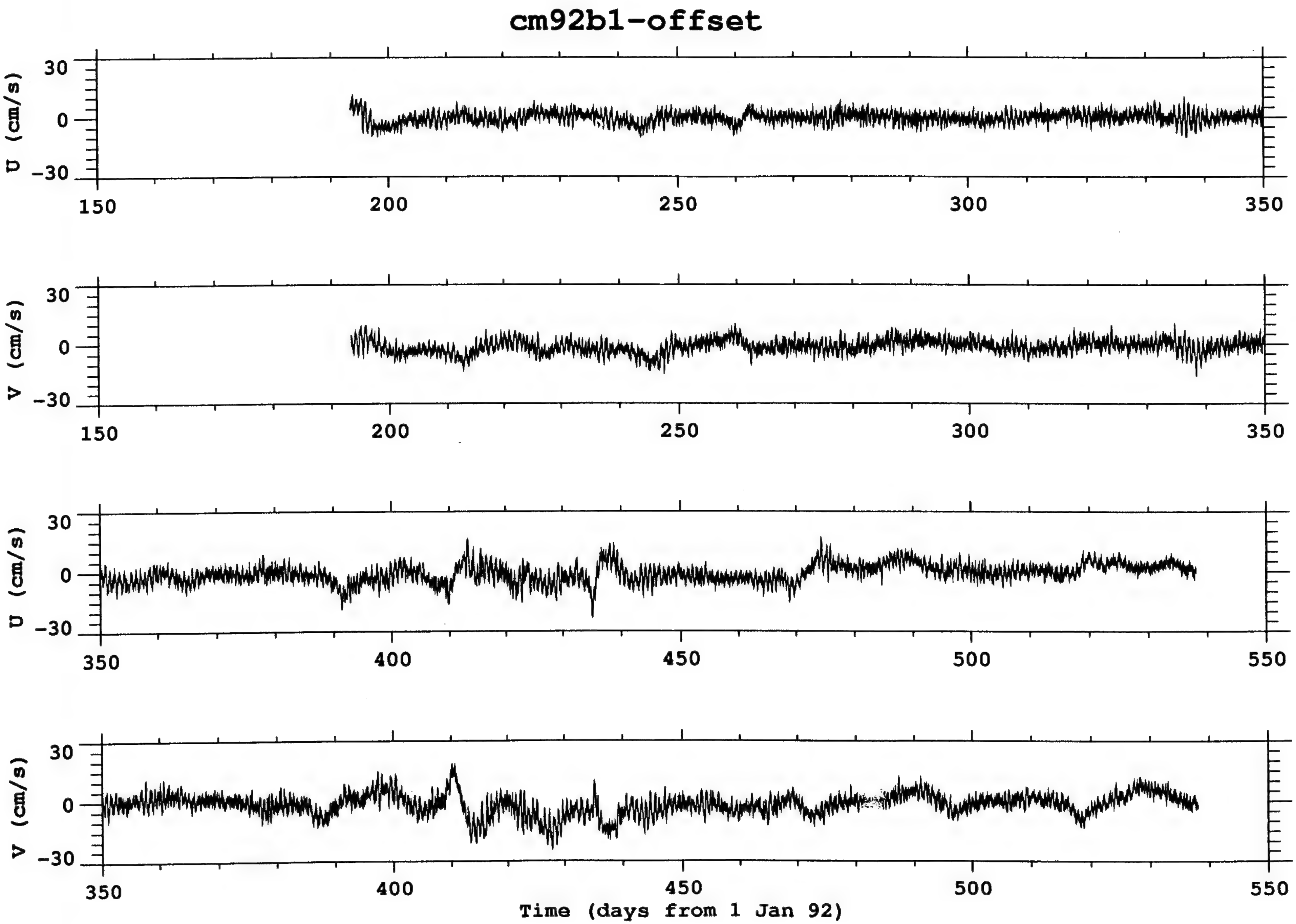
450
500
550
Time (days from 1 Jan 93)


cm92b1-offset
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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150
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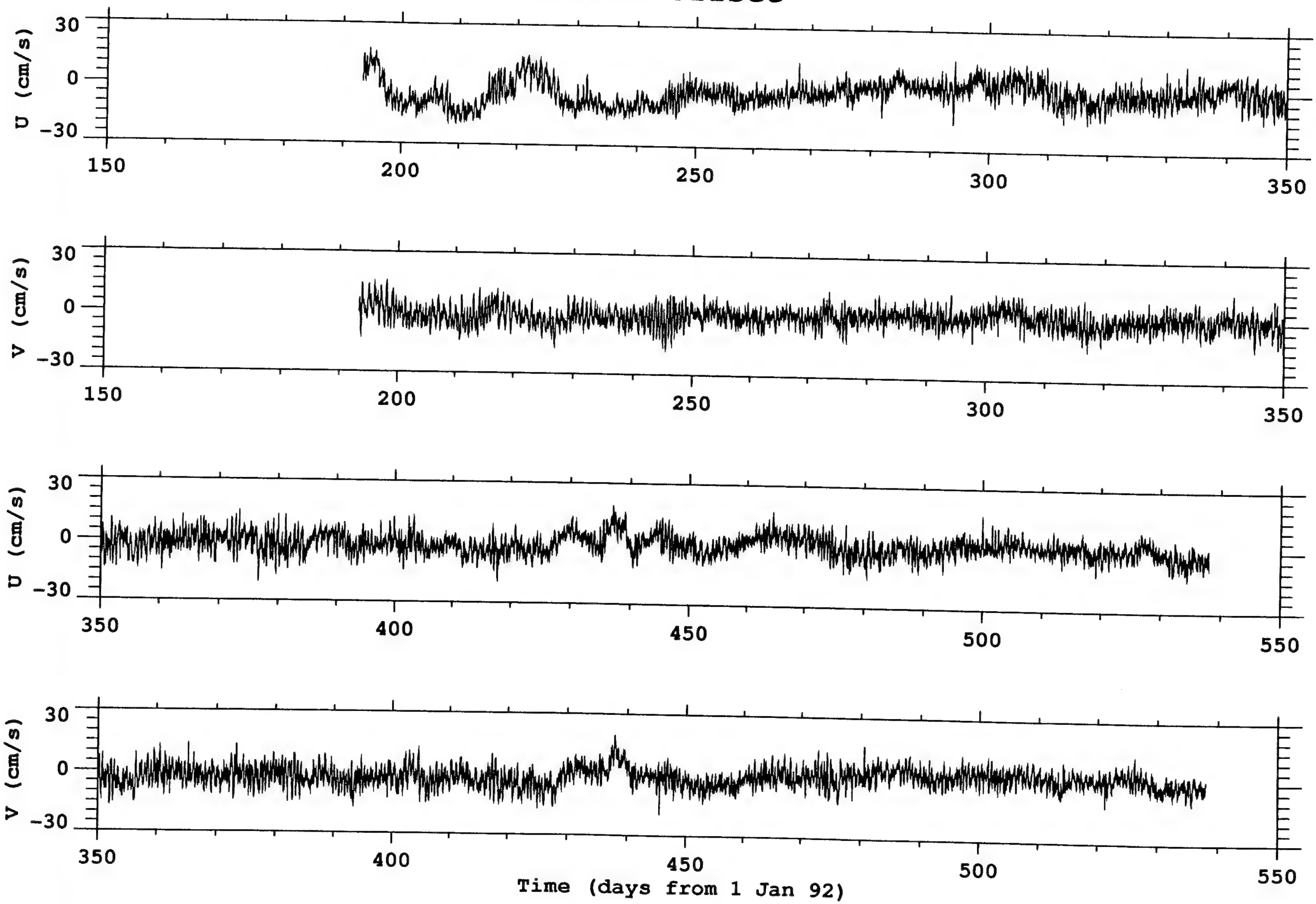
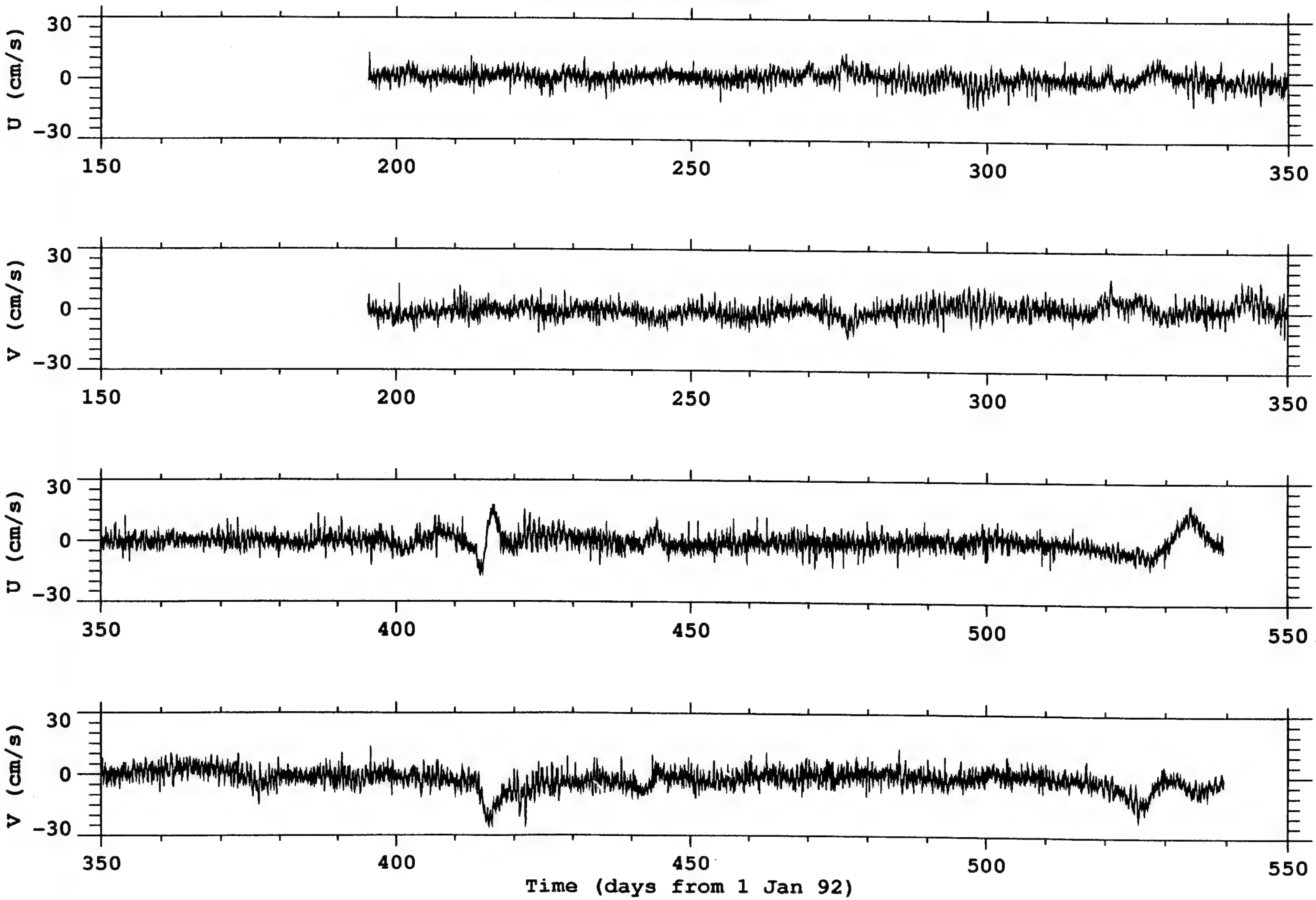
350
400
450
500
550
Time (days from 1 Jan 92)

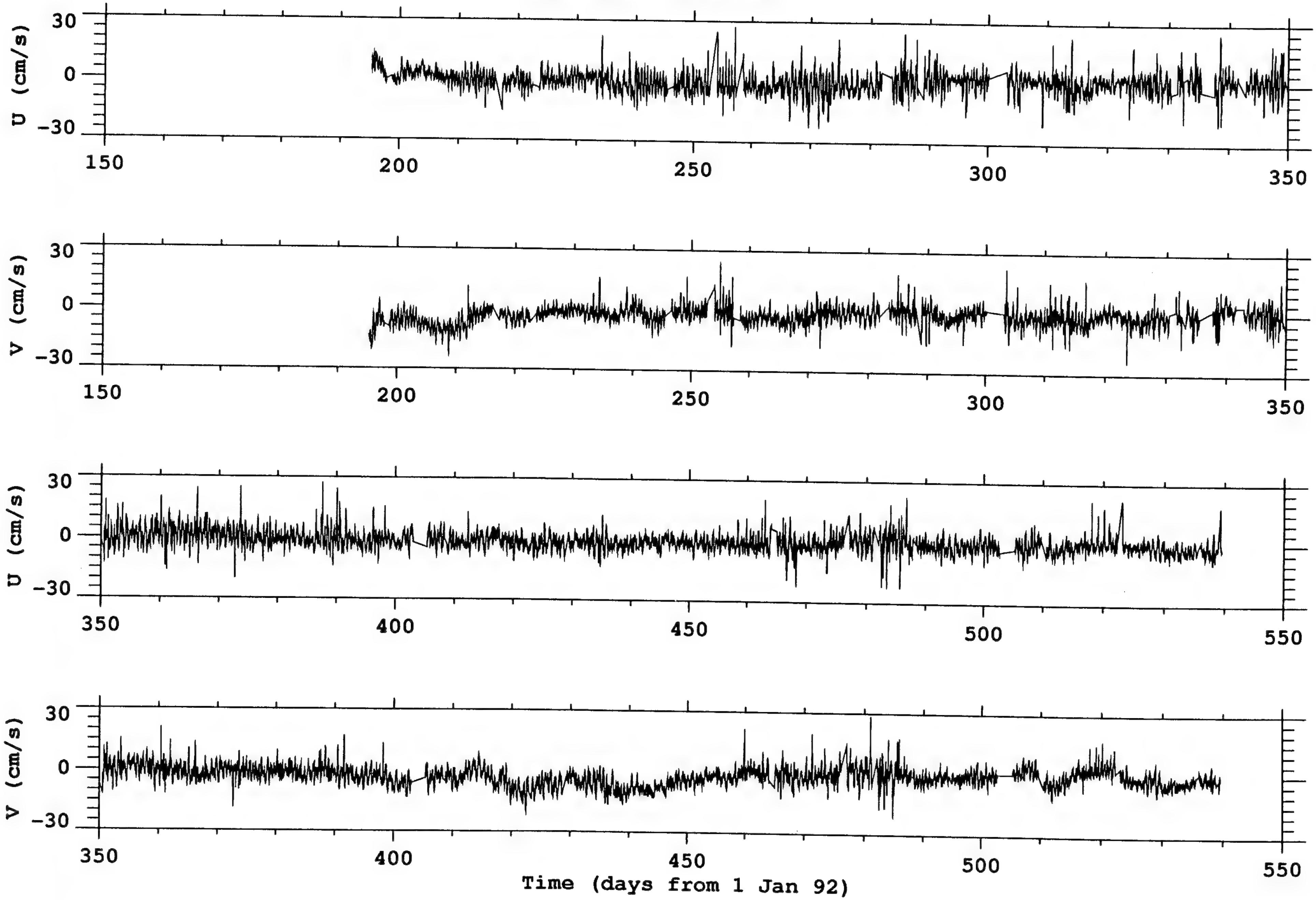
cm92b2-offset



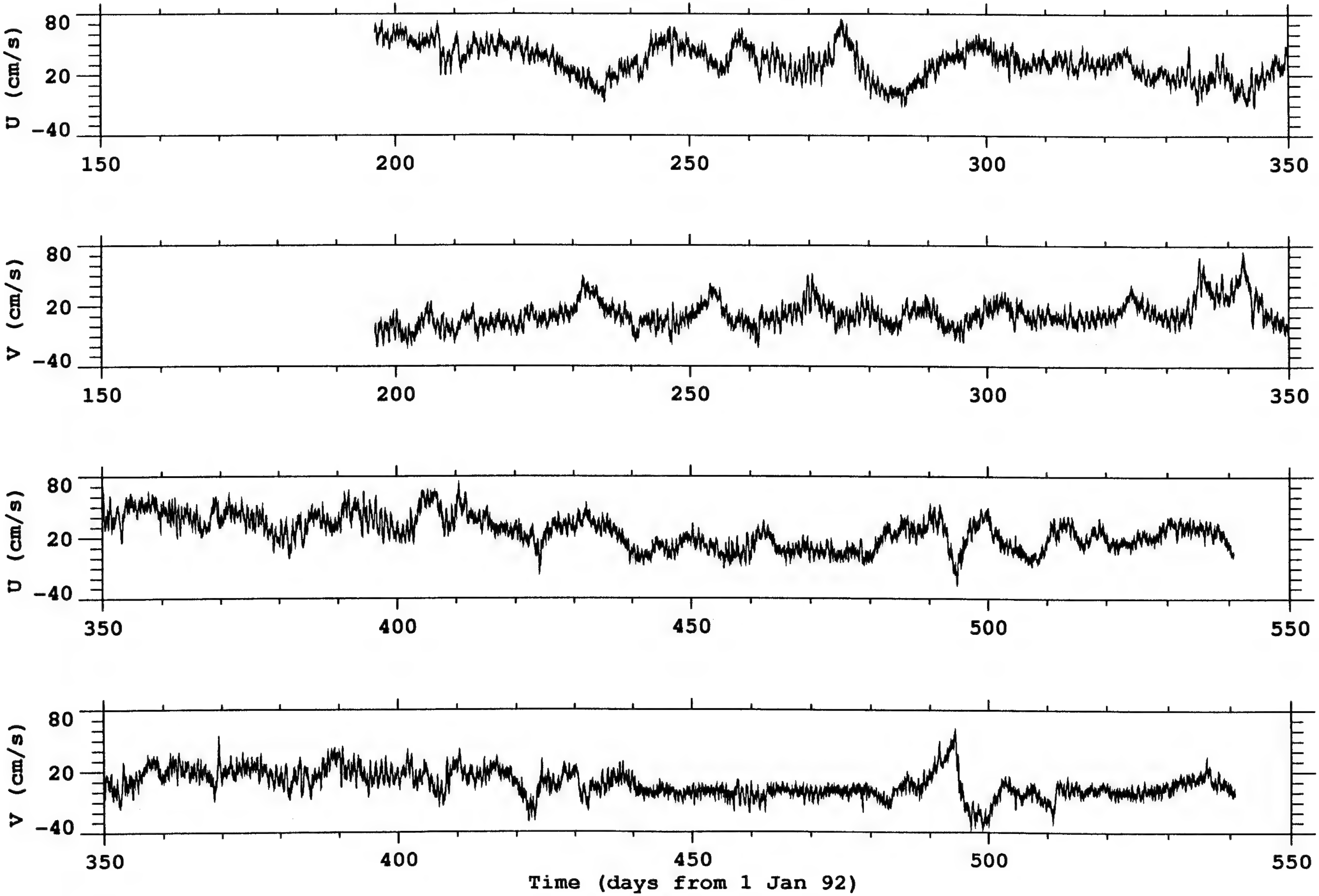
cm92c1-offset



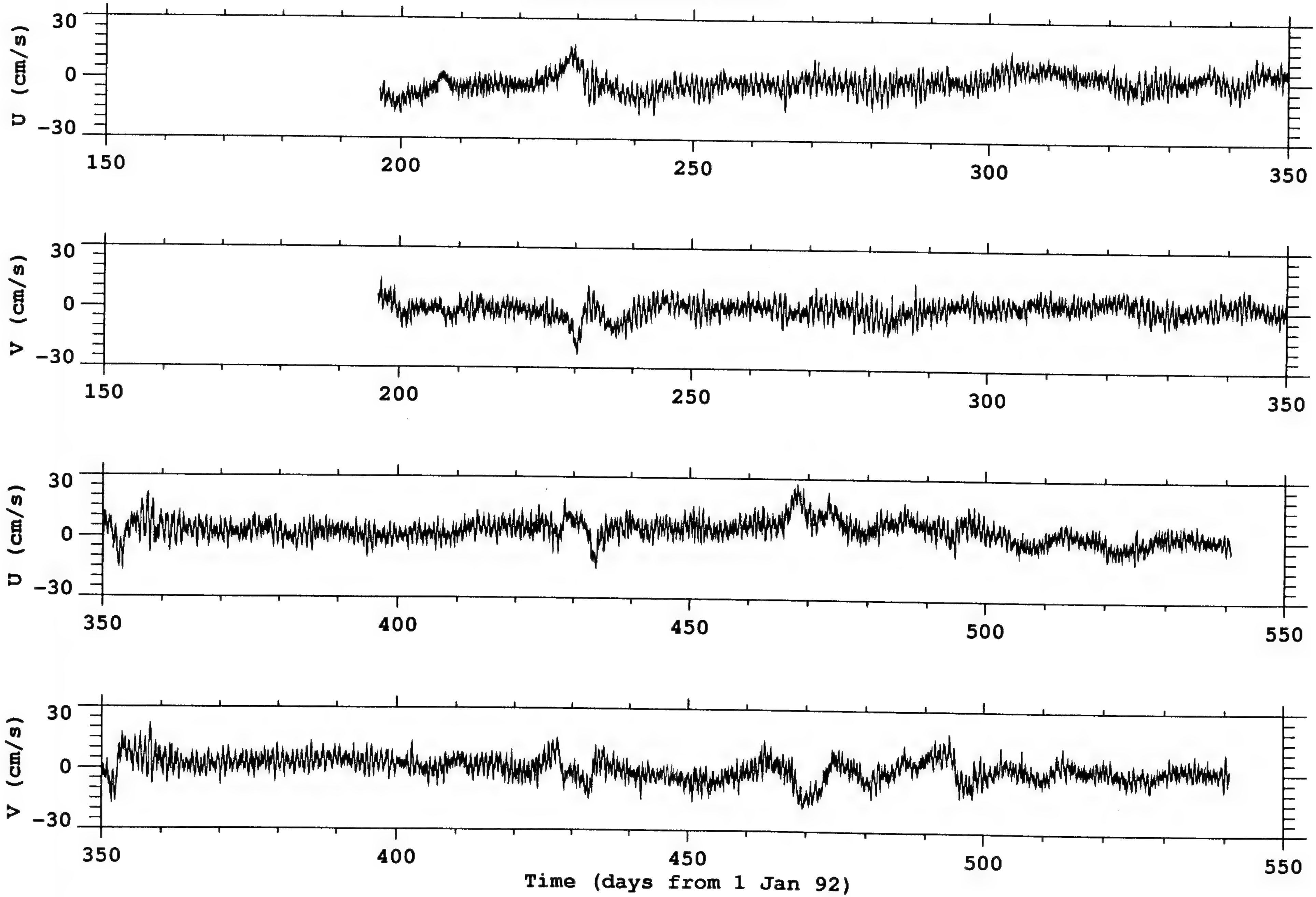
cm92c3-offset



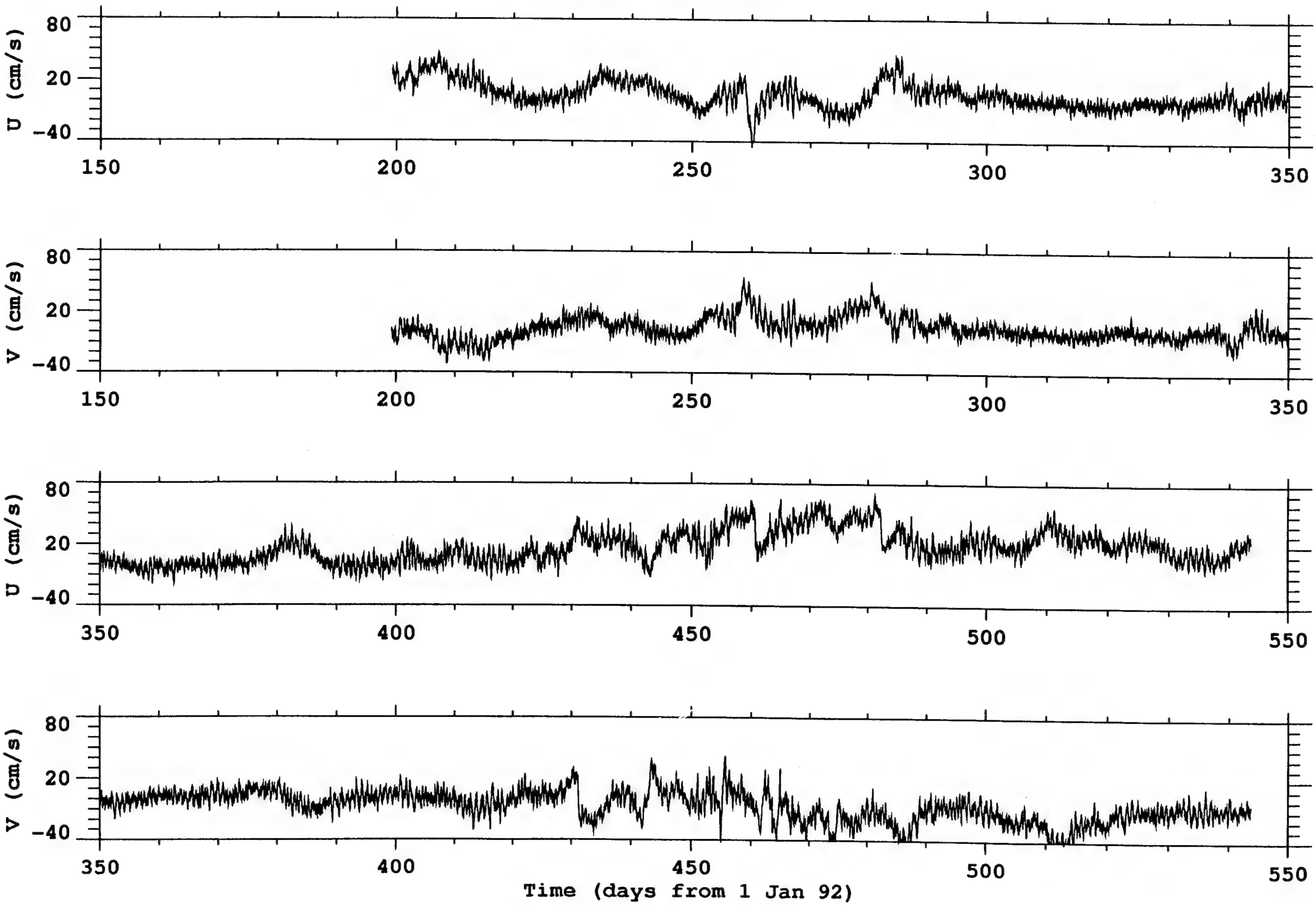
cm92d1-offset

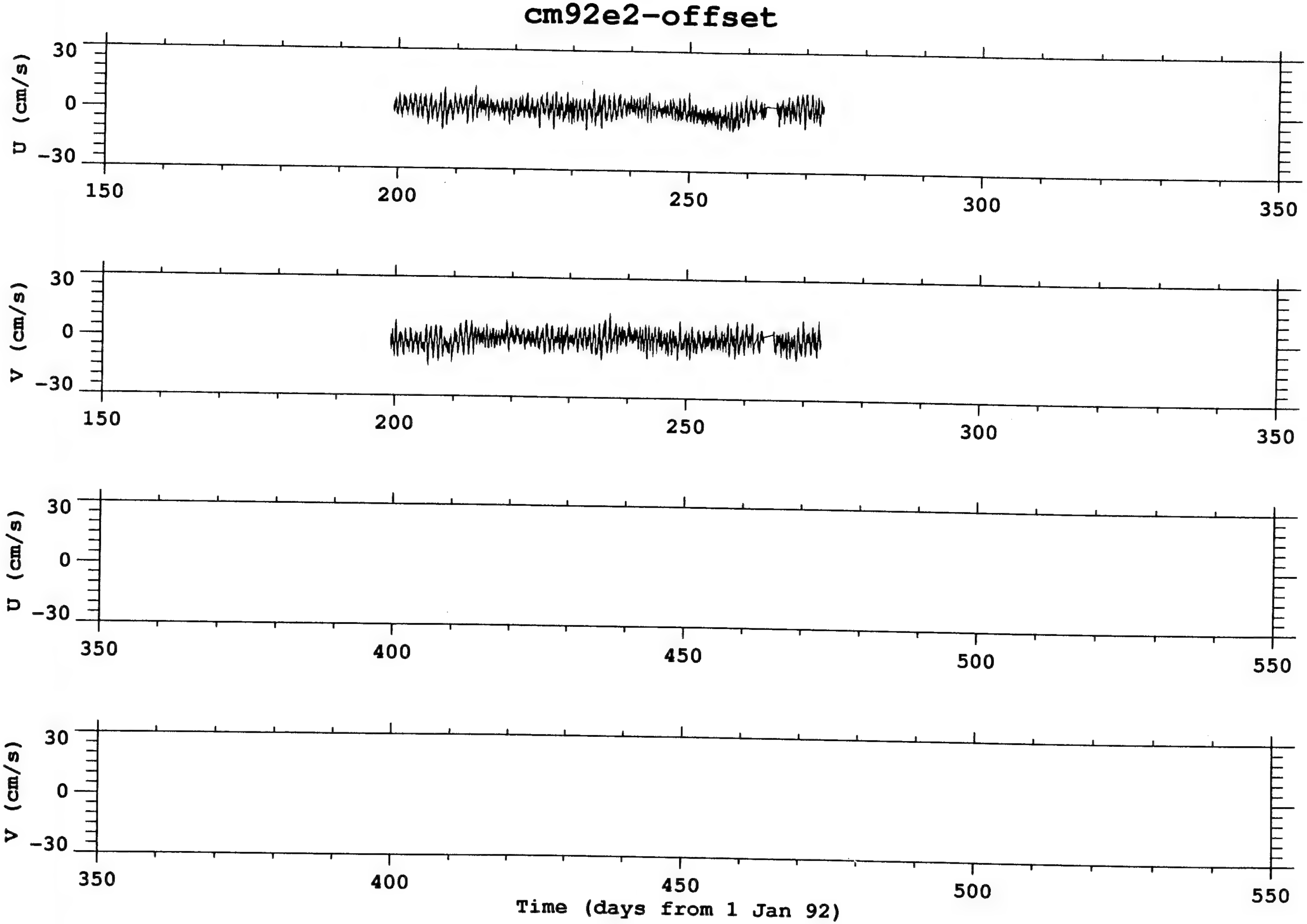


cm92d2-offset



cm92e1-offset




cm92e2-offset
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V (cm/s)
U (cm/s)
V (cm/s)
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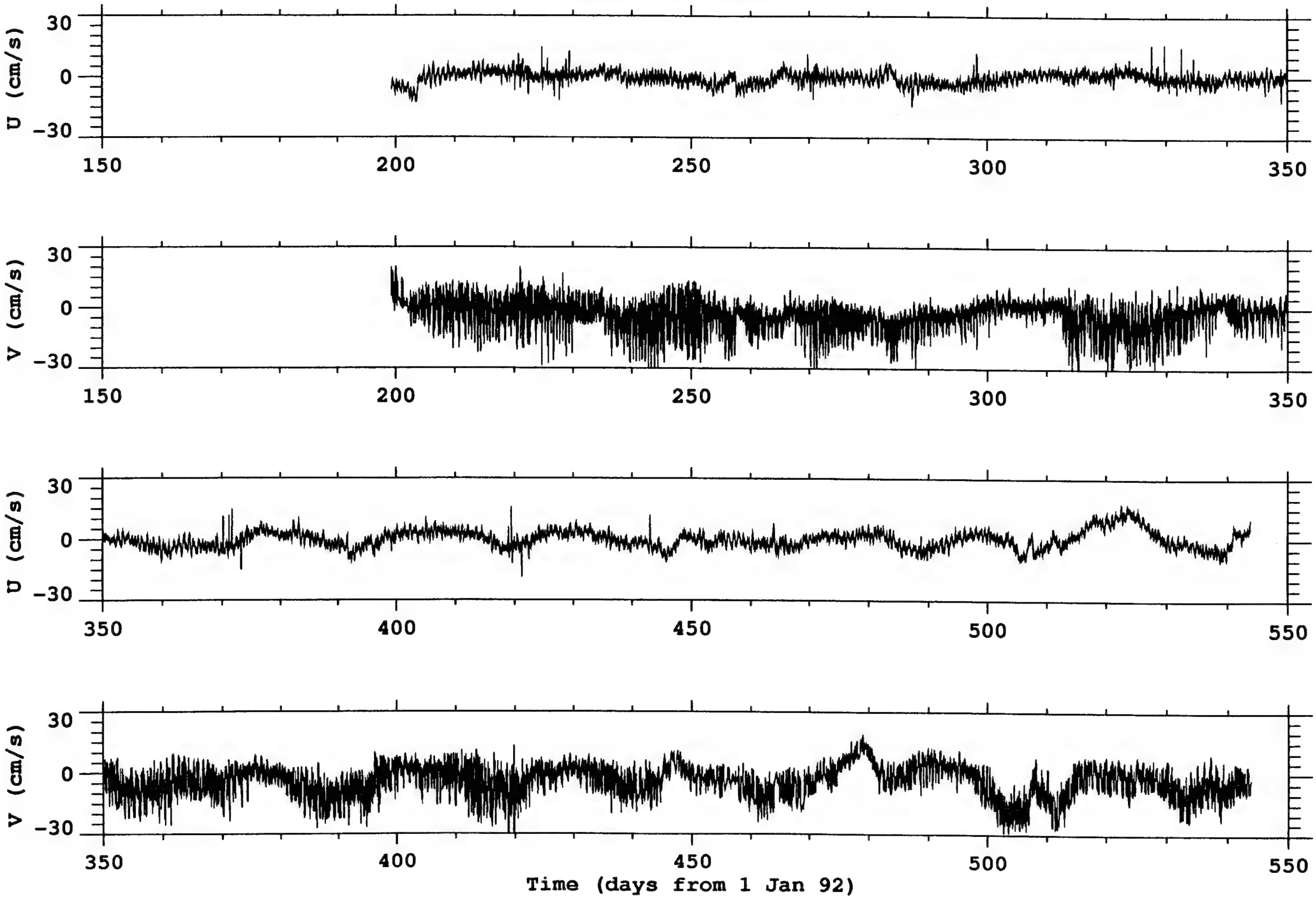
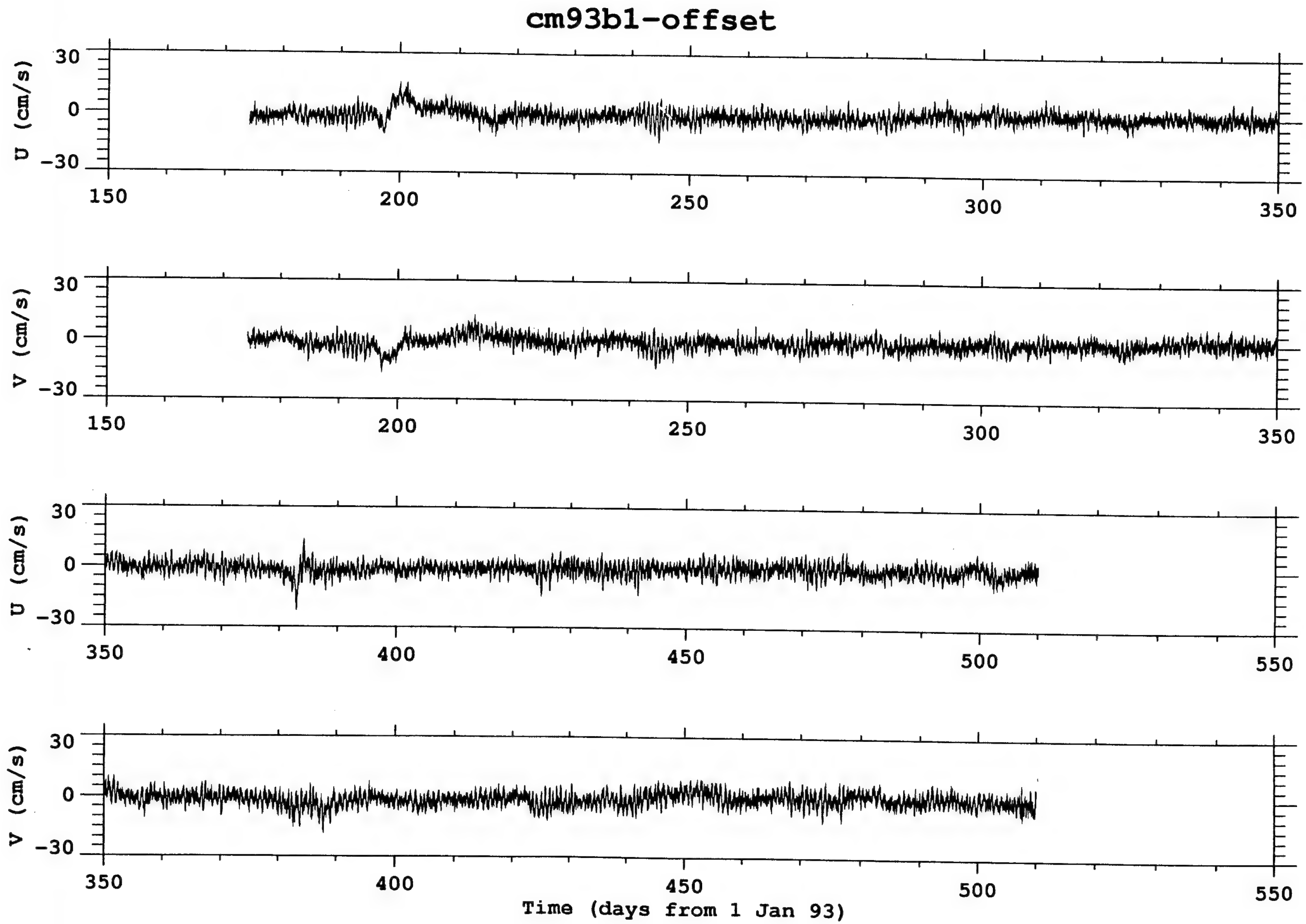
550
Time (days from 1 Jan 92)

cm92e4-offset




cm93b1-offset
U (cm/s)
V (cm/s)
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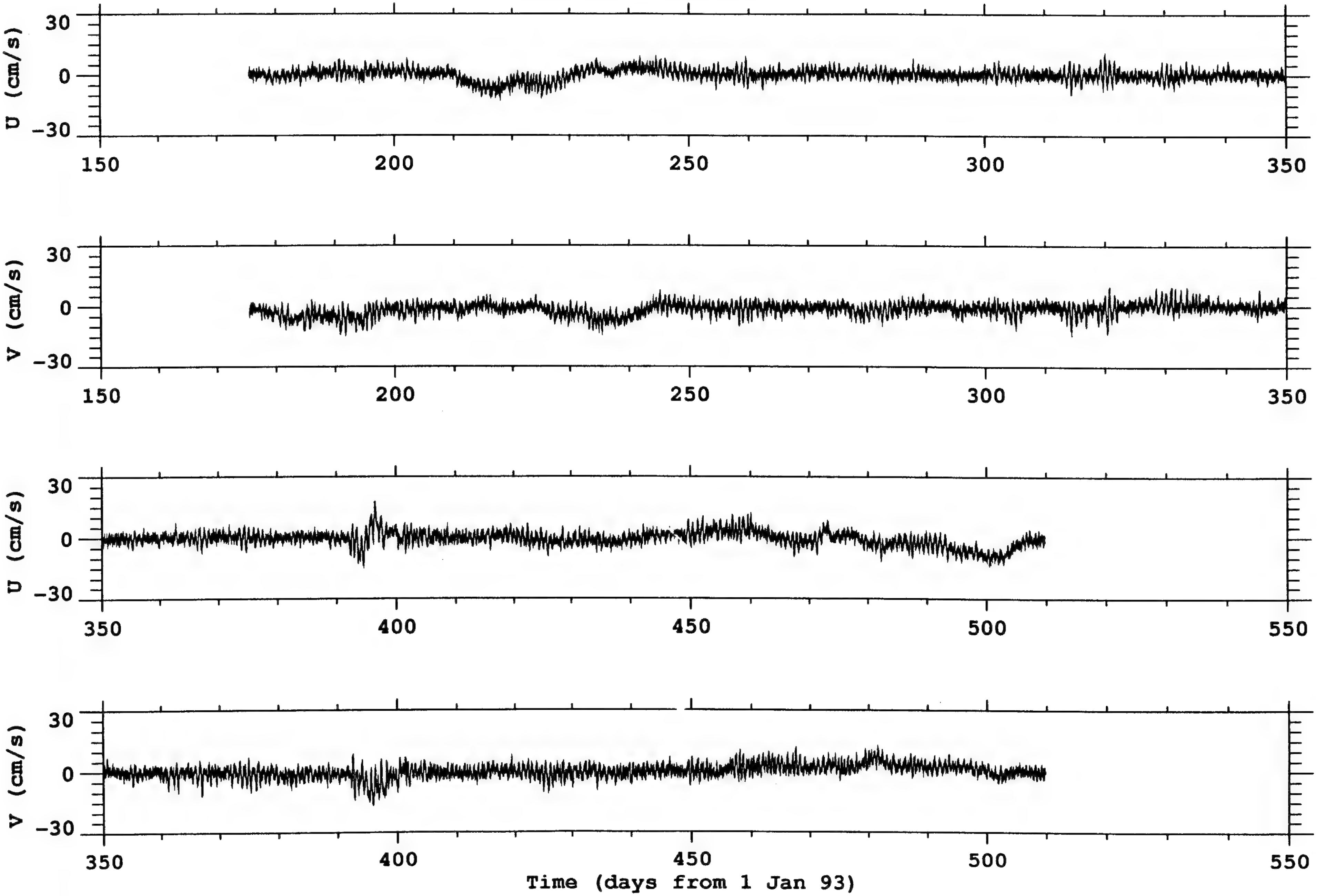
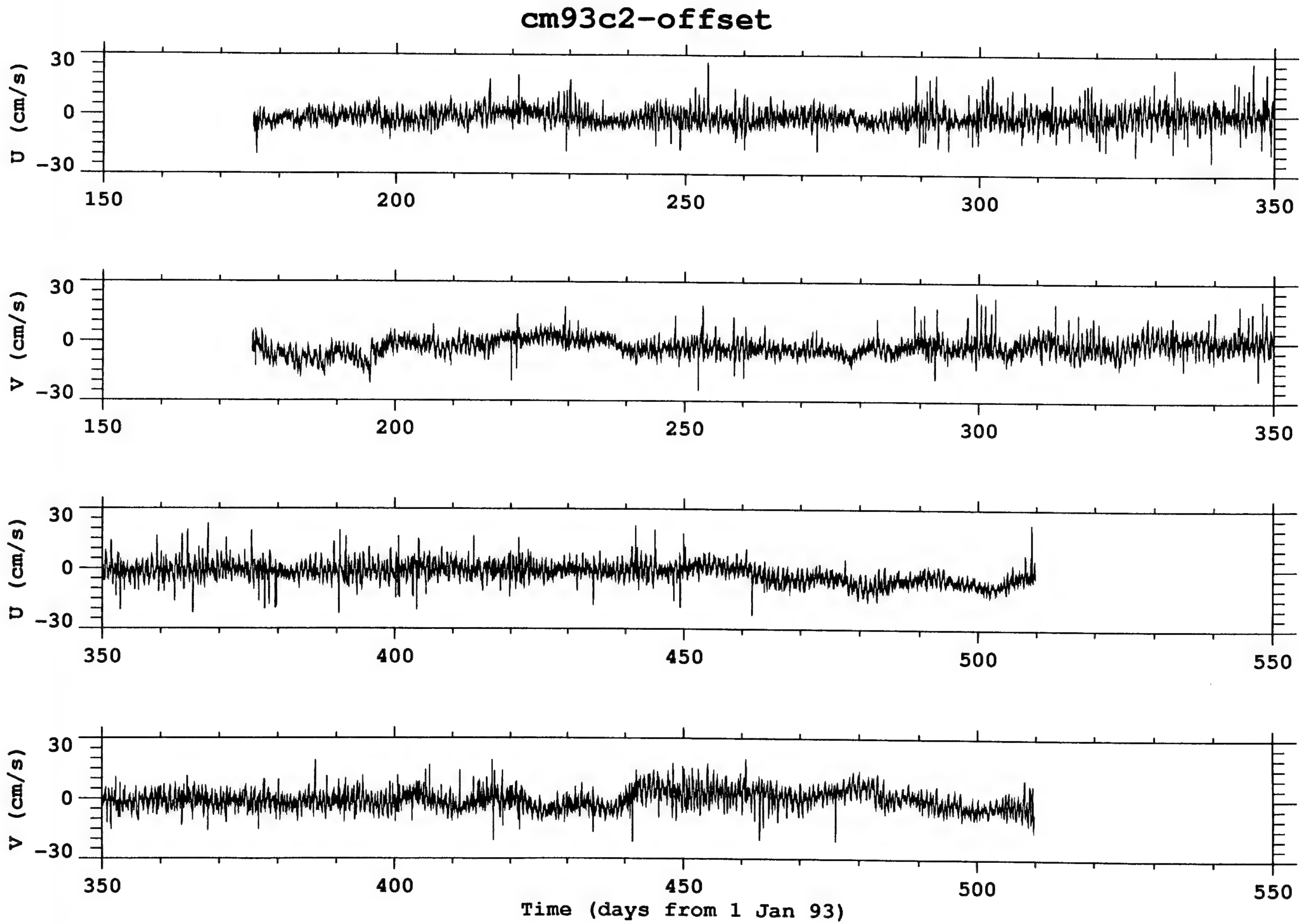
550
Time (days from 1 Jan 93)

cm93c1-offset




cm93c2-offset
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V (cm/s)
U (cm/s)
V (cm/s)
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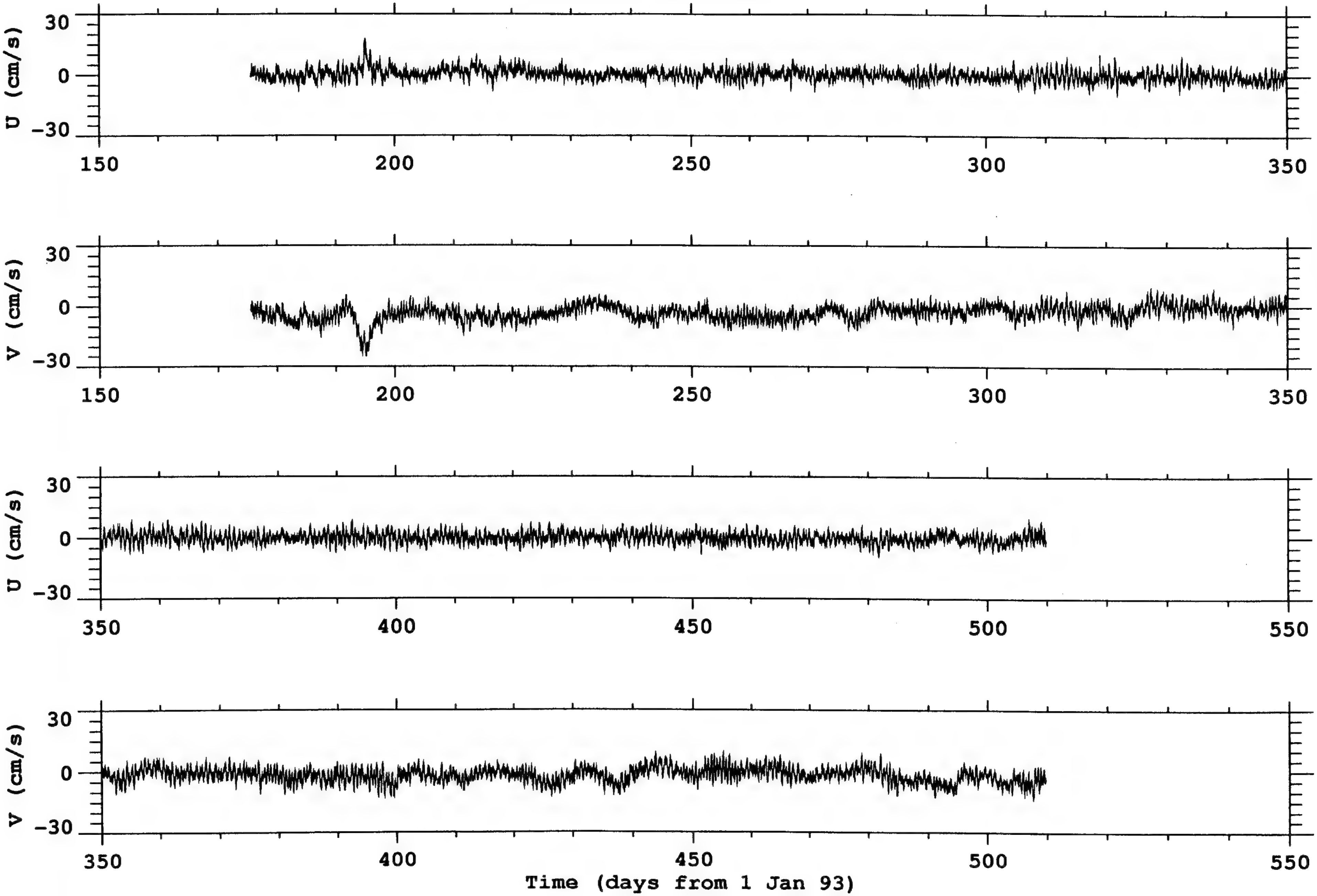
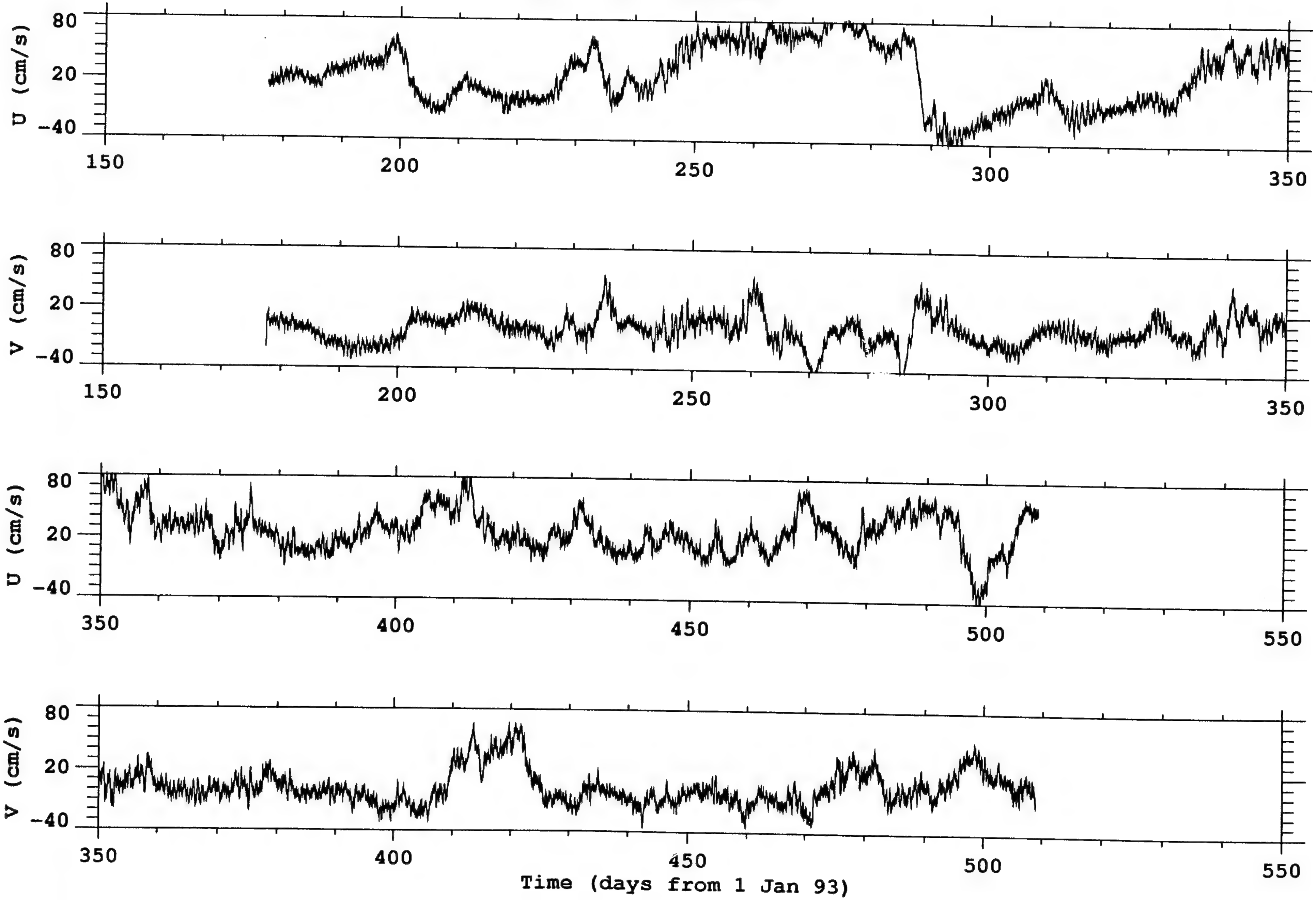
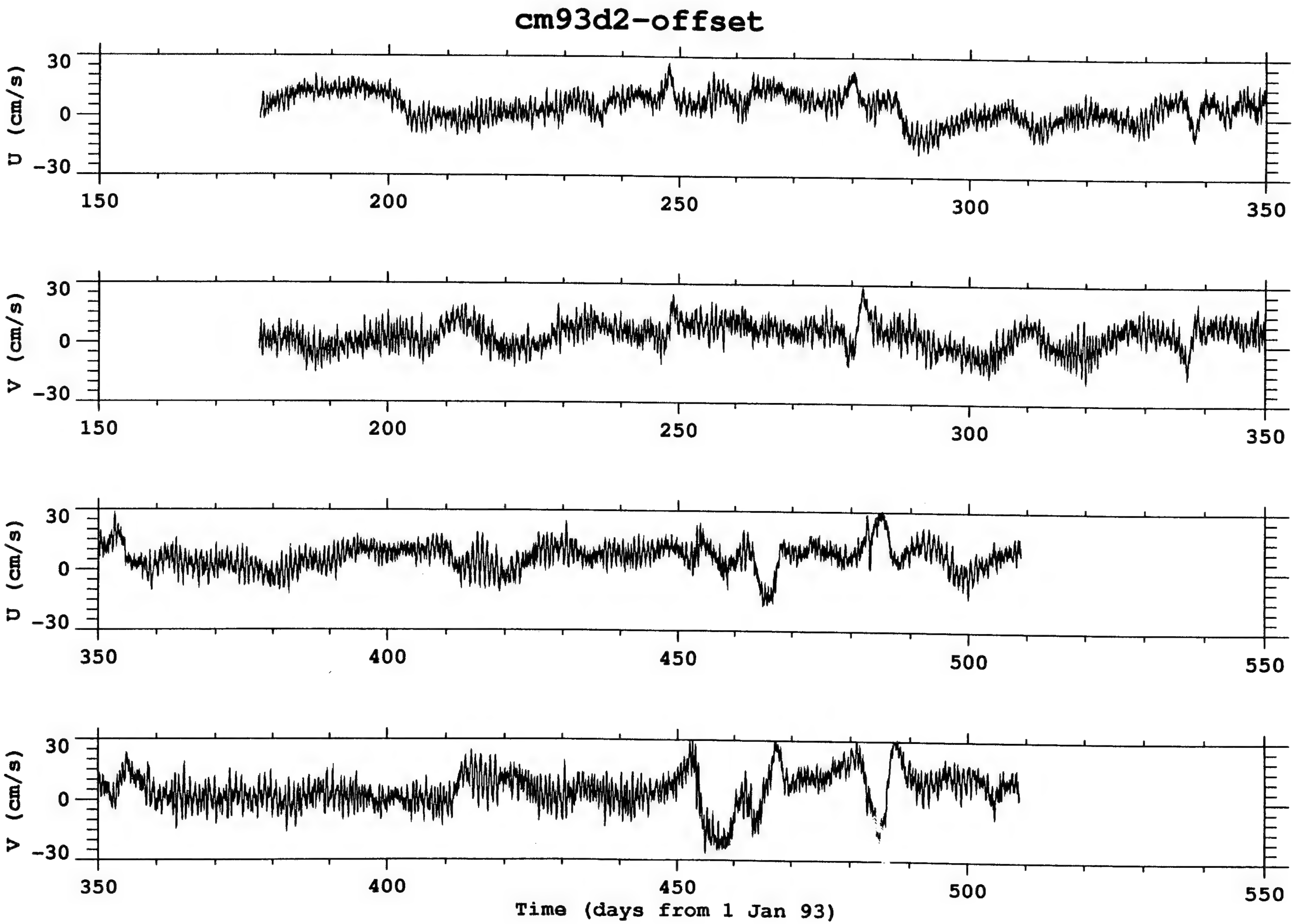
Time (days from 1 Jan 93)

cm93c3-offset



cm93d1-offset




cm93d2-offset
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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150
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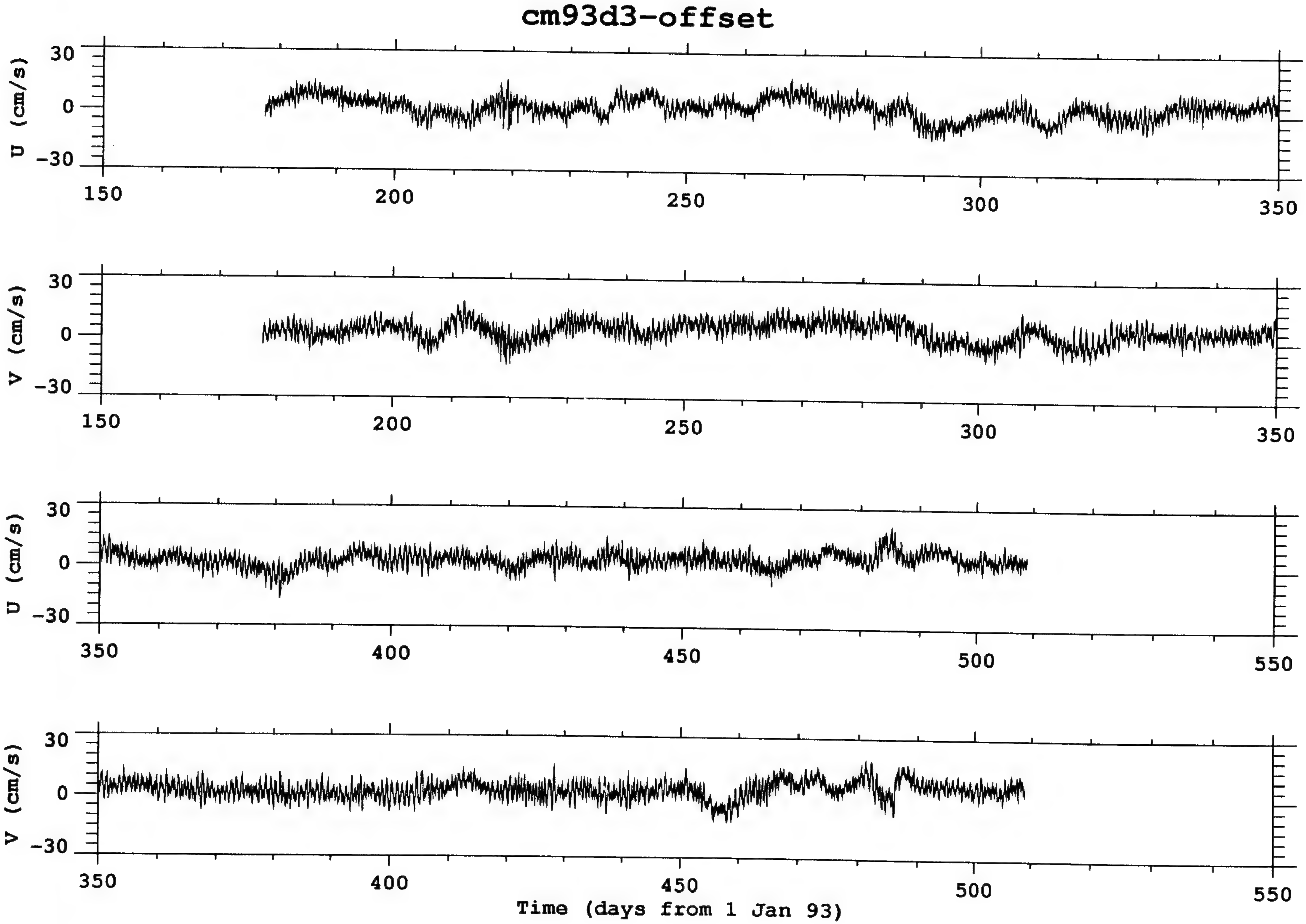
550
Time (days from 1 Jan 93)


cm93d3-offset
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U (cm/s)
30
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−30
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V (cm/s)
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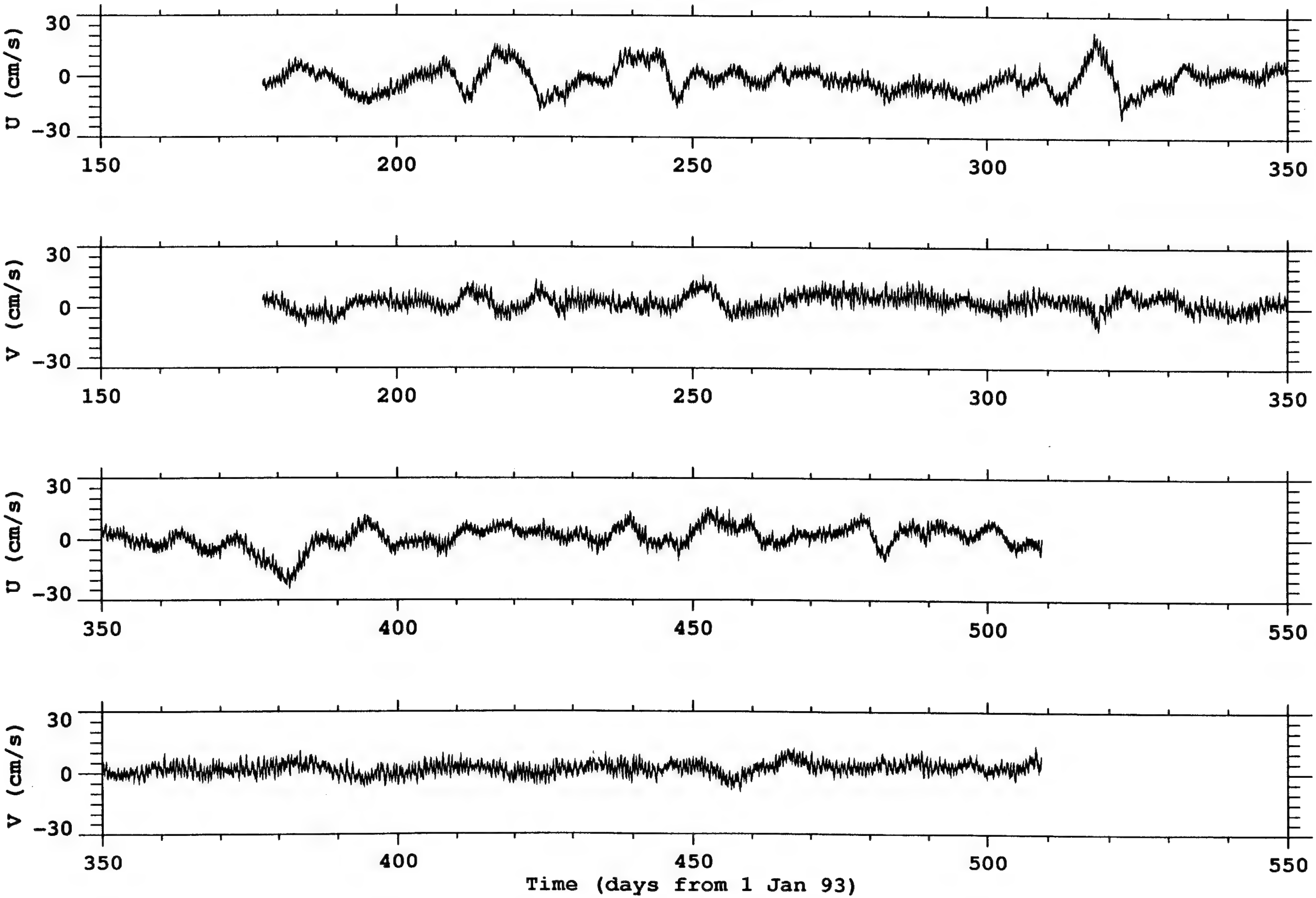
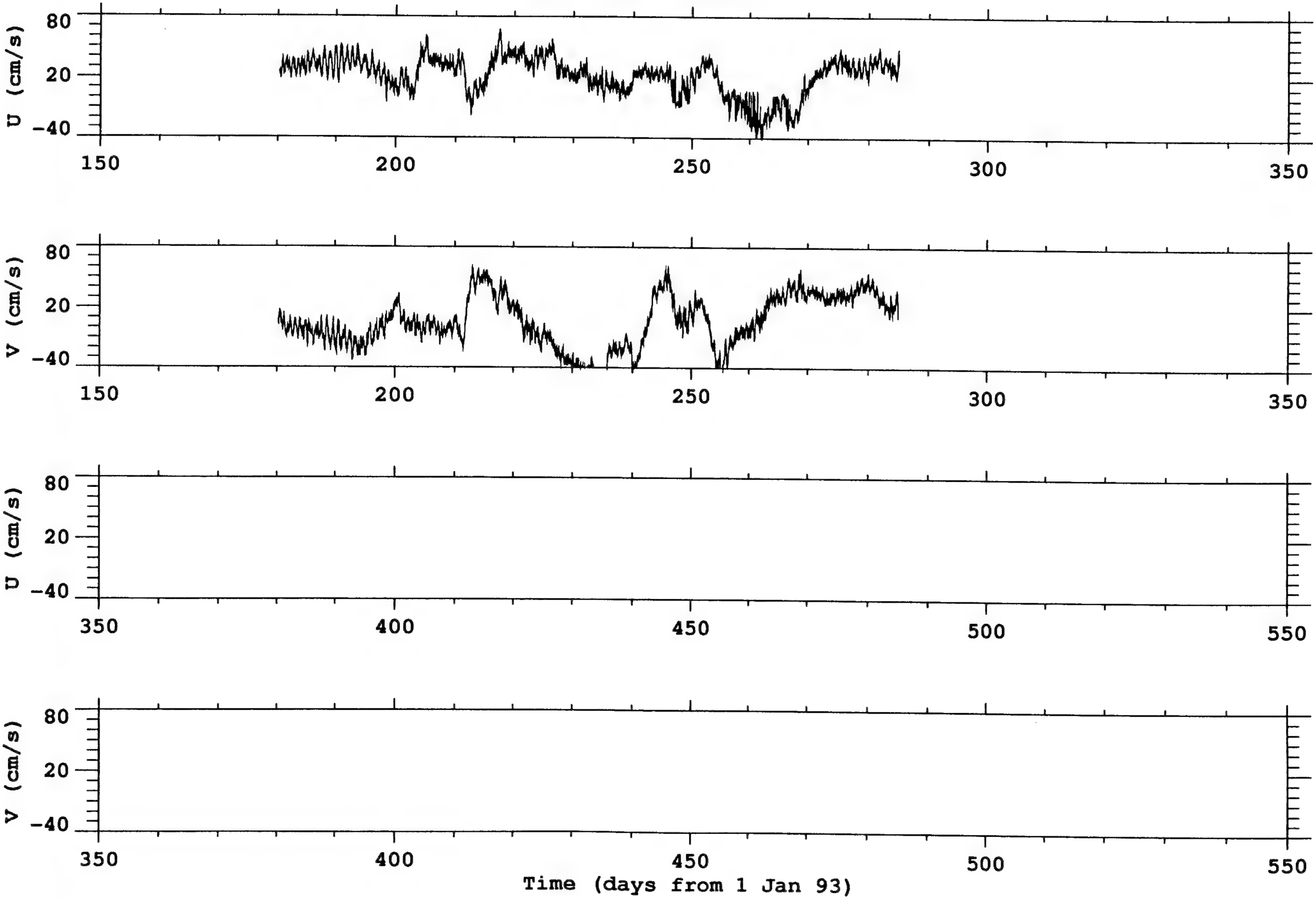
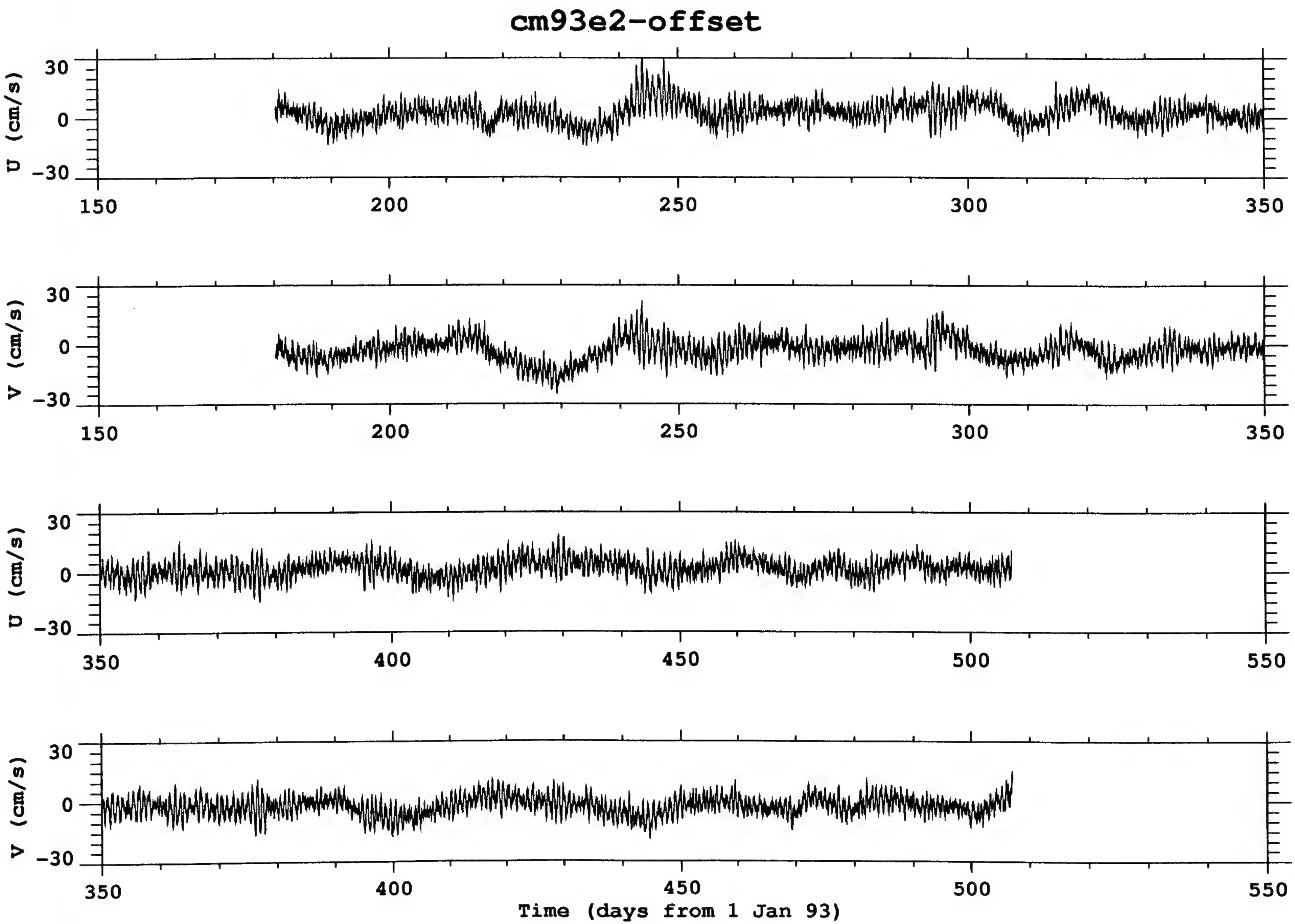
500
550
Time (days from 1 Jan 93)

cm93d4-offset



cm93e1-offset




cm93e2-offset
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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0
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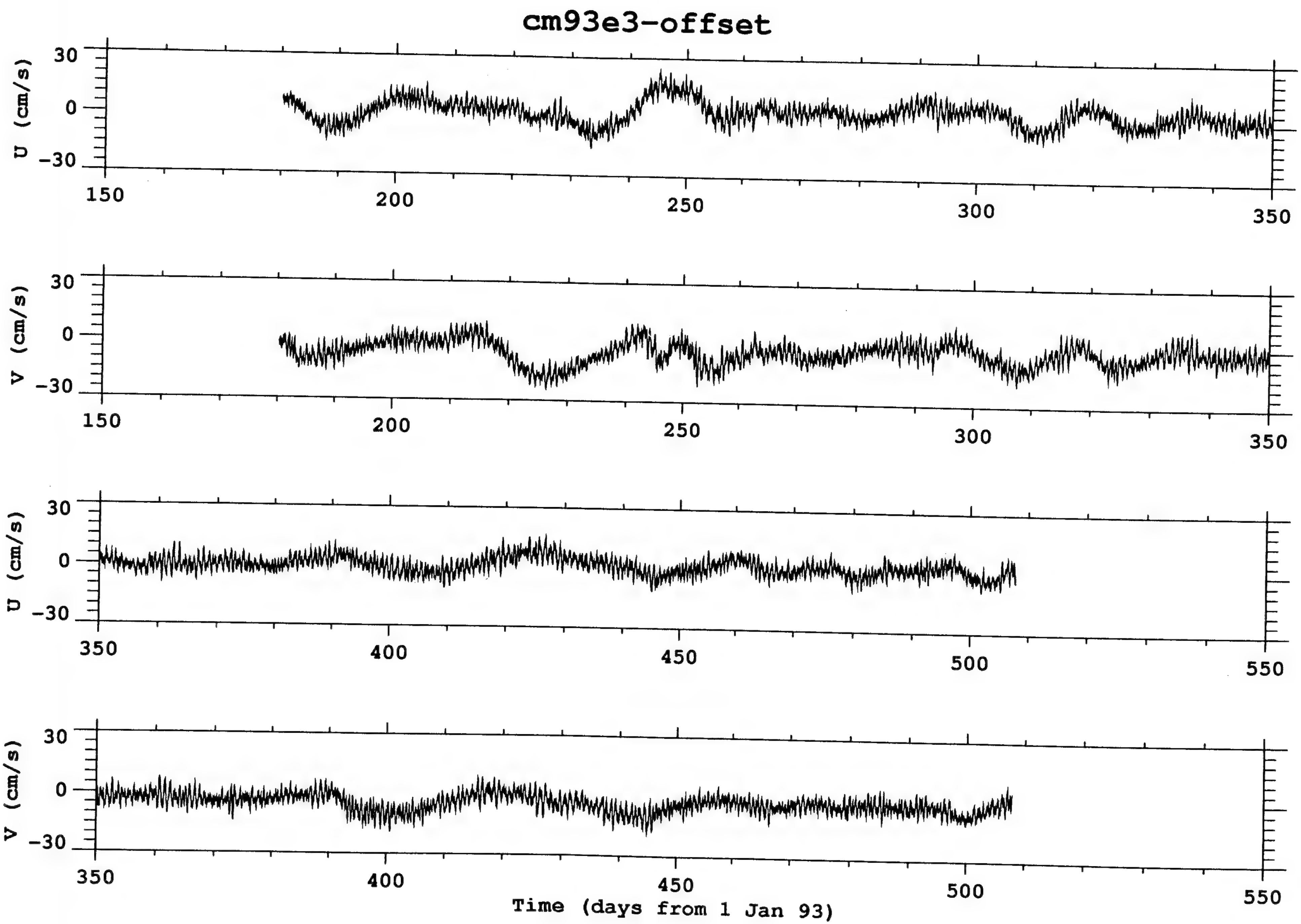
550
Time (days from 1 Jan 93)


cm93e3-offset
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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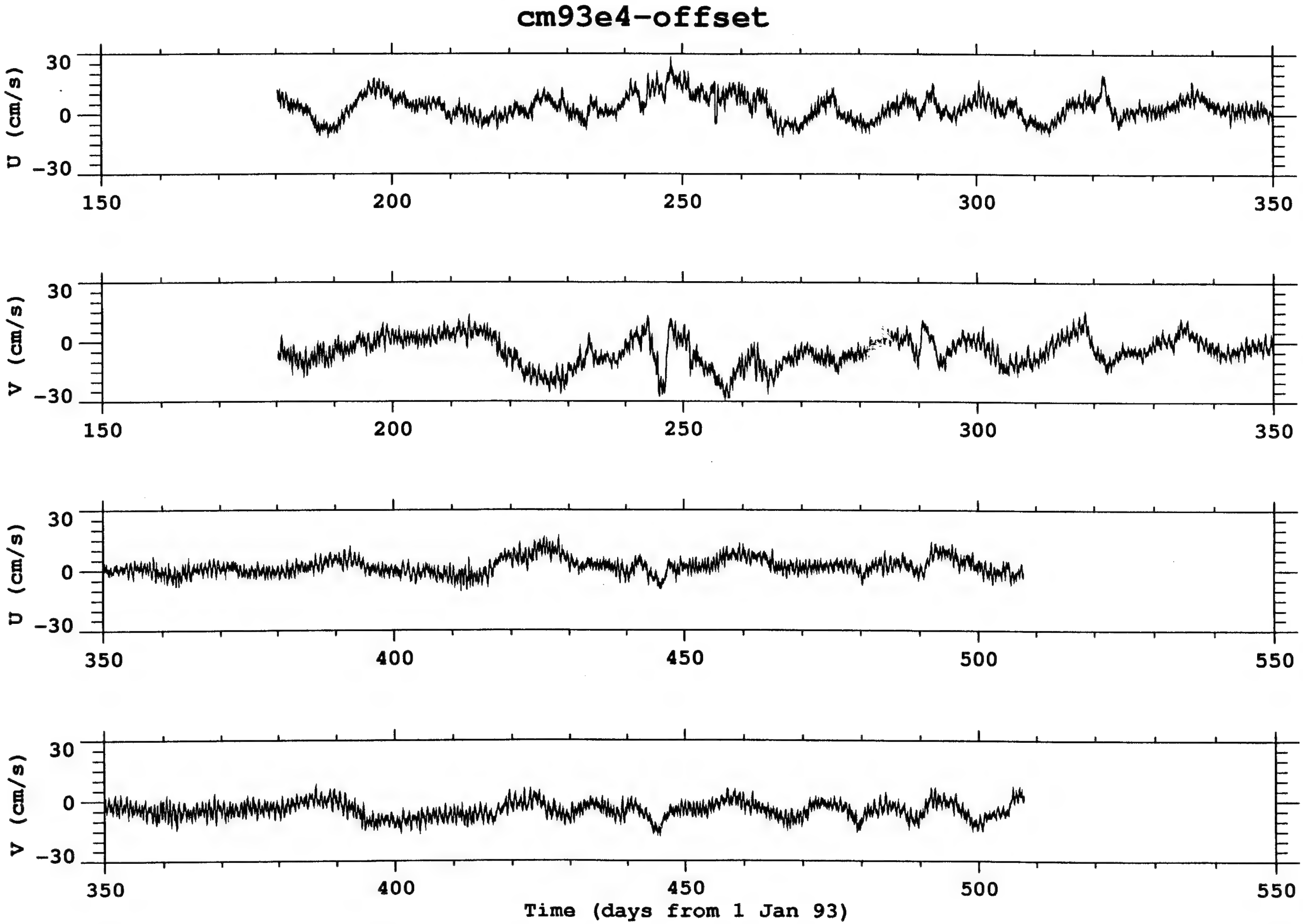
550
Time (days from 1 Jan 93)


cm93e4-offset
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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200
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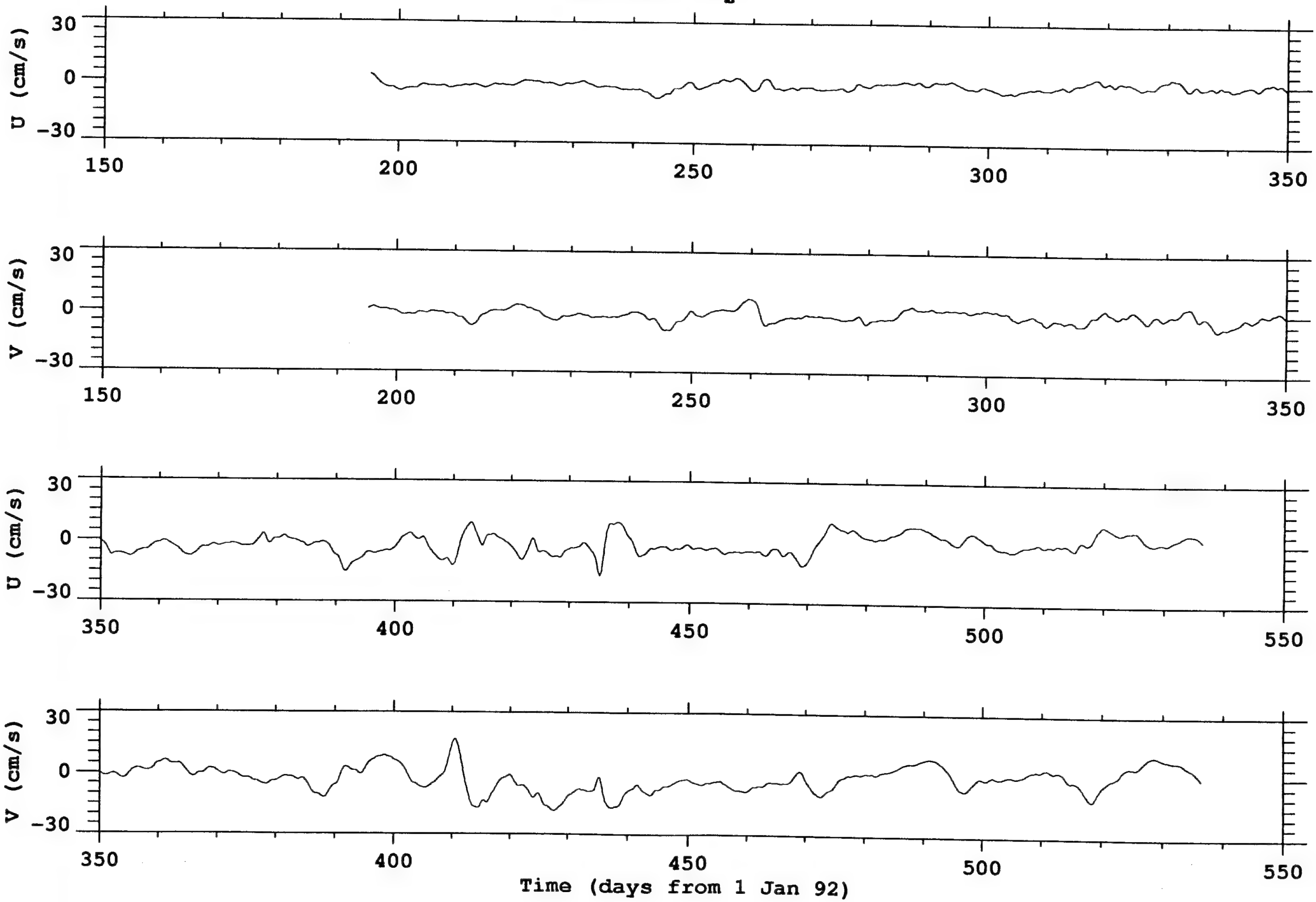
400
450
500
550
Time (days from 1 Jan 93)

cm92b1-1p


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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150
200
250
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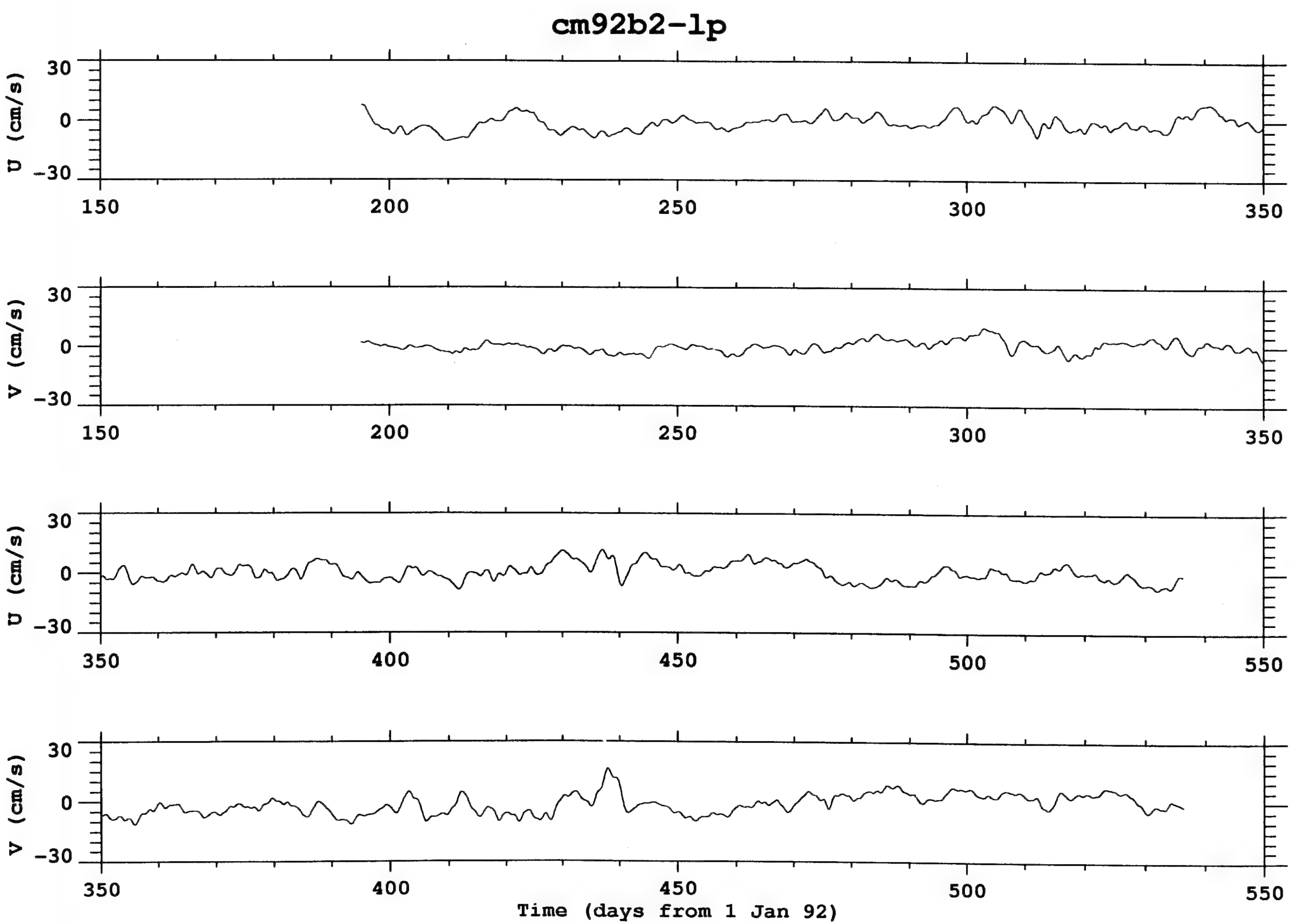
400
450
500
550
Time (days from 1 Jan 92)


cm92b2-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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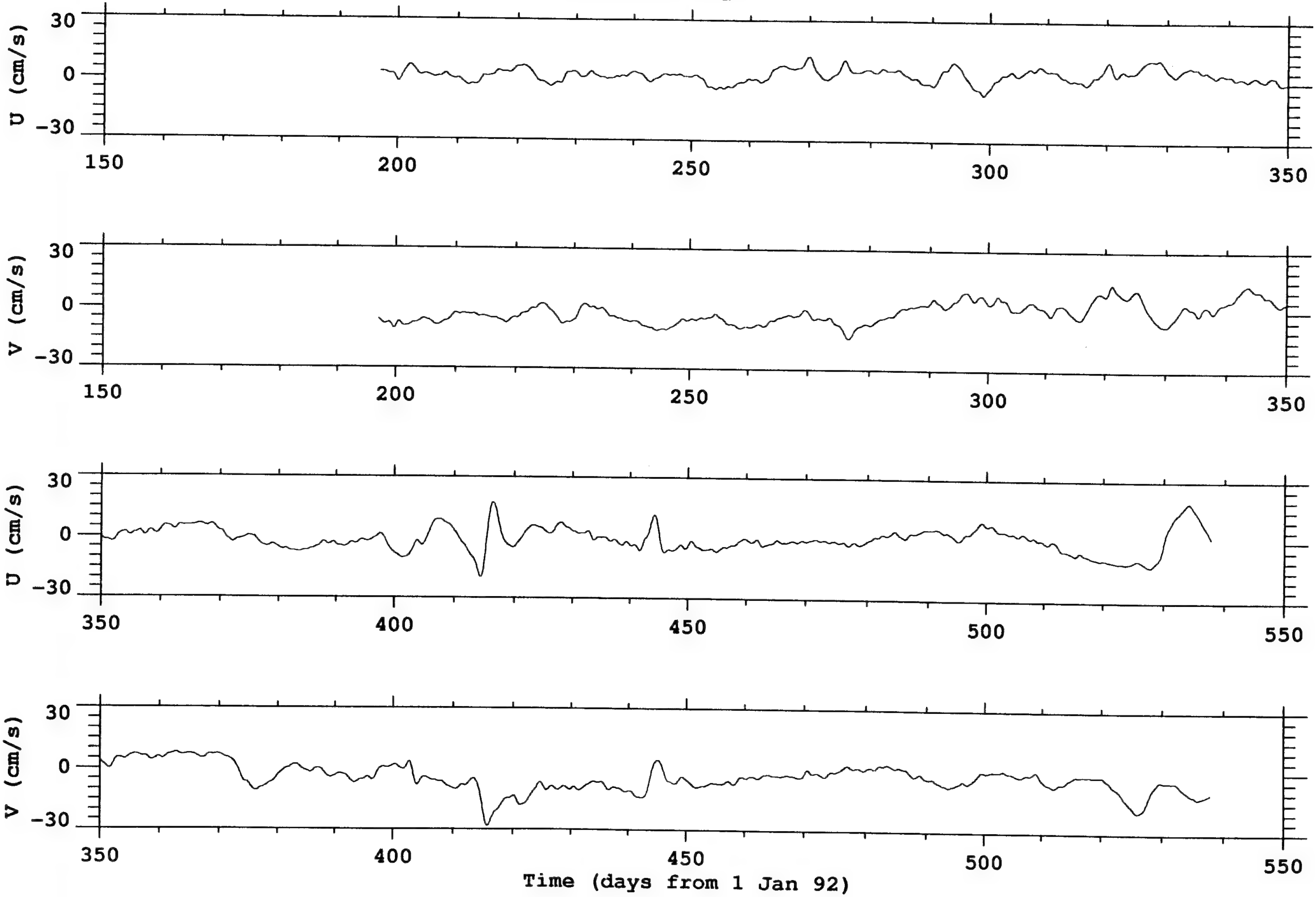
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92c1-lp



U (cm/s)
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0
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150
200
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300
350
V (cm/s)
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0
-30
150
200
250
300
350
U (cm/s)
30
0
-30
350
400
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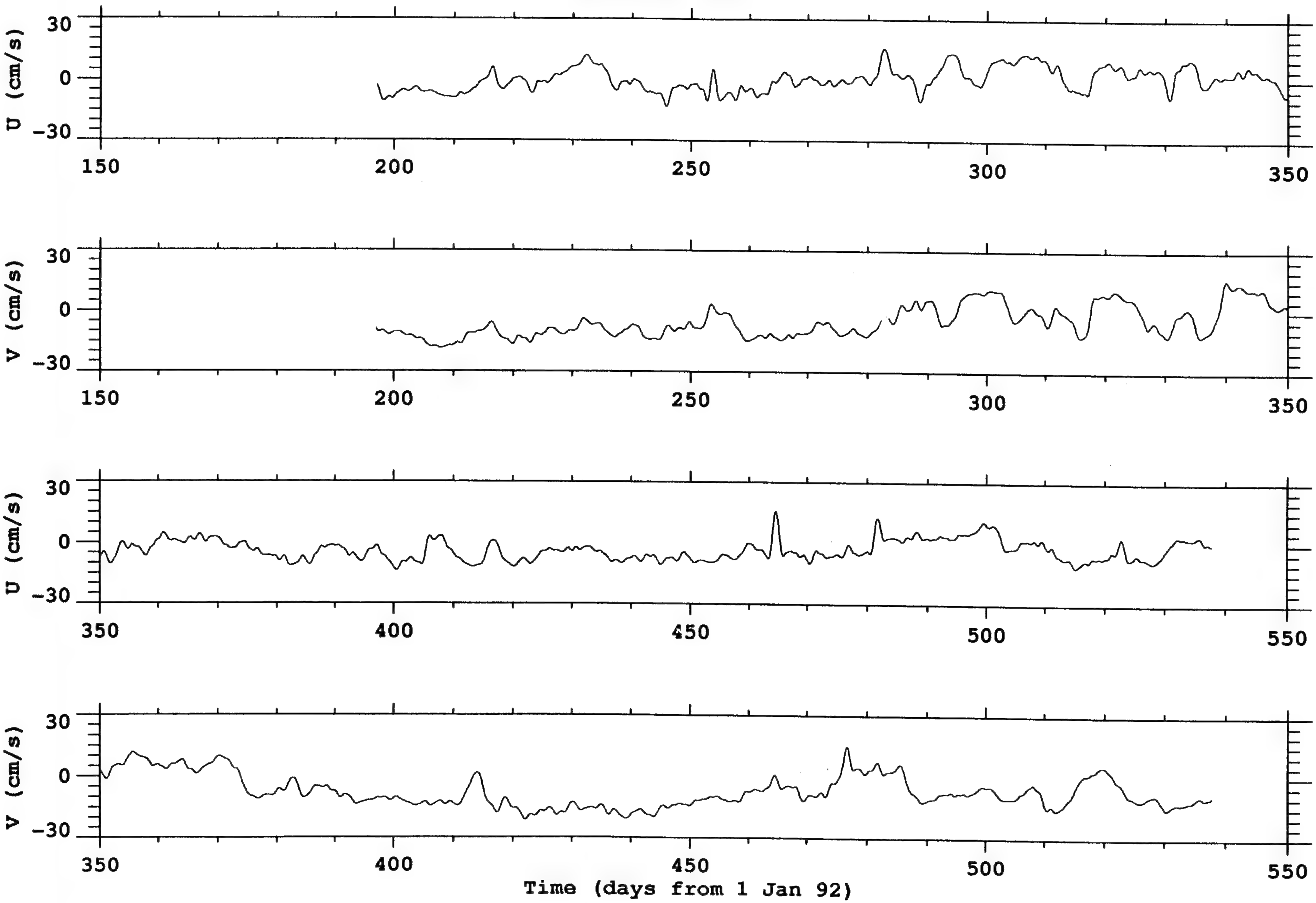
V (cm/s)
30
0
-30
350
400
450
500
550
Time (days from 1 Jan 92)

cm92c3-1p



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
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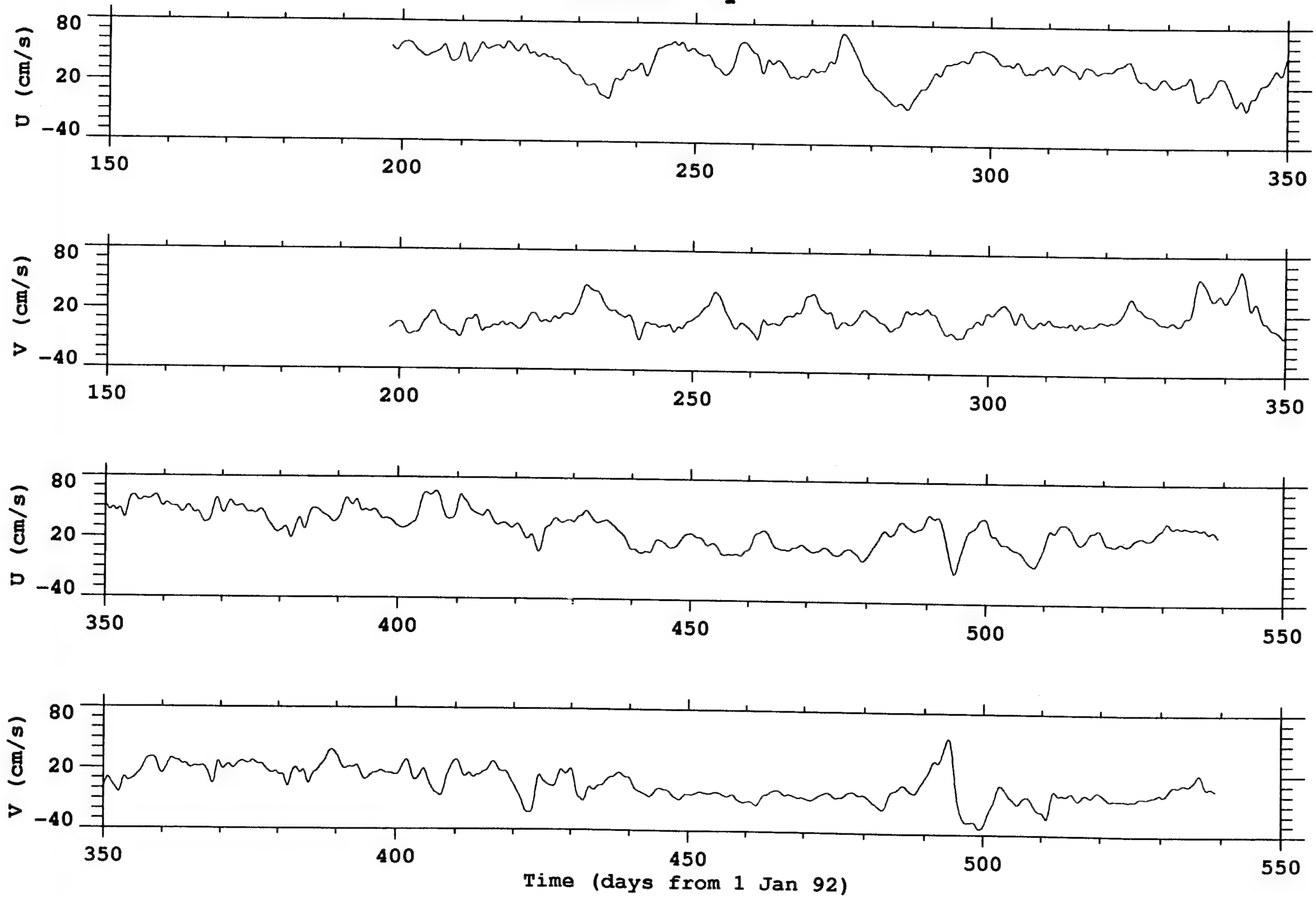
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92d1-1p


U (cm/s)
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V (cm/s)
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20
-40
150
200
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U (cm/s)
80
20
-40
350
400
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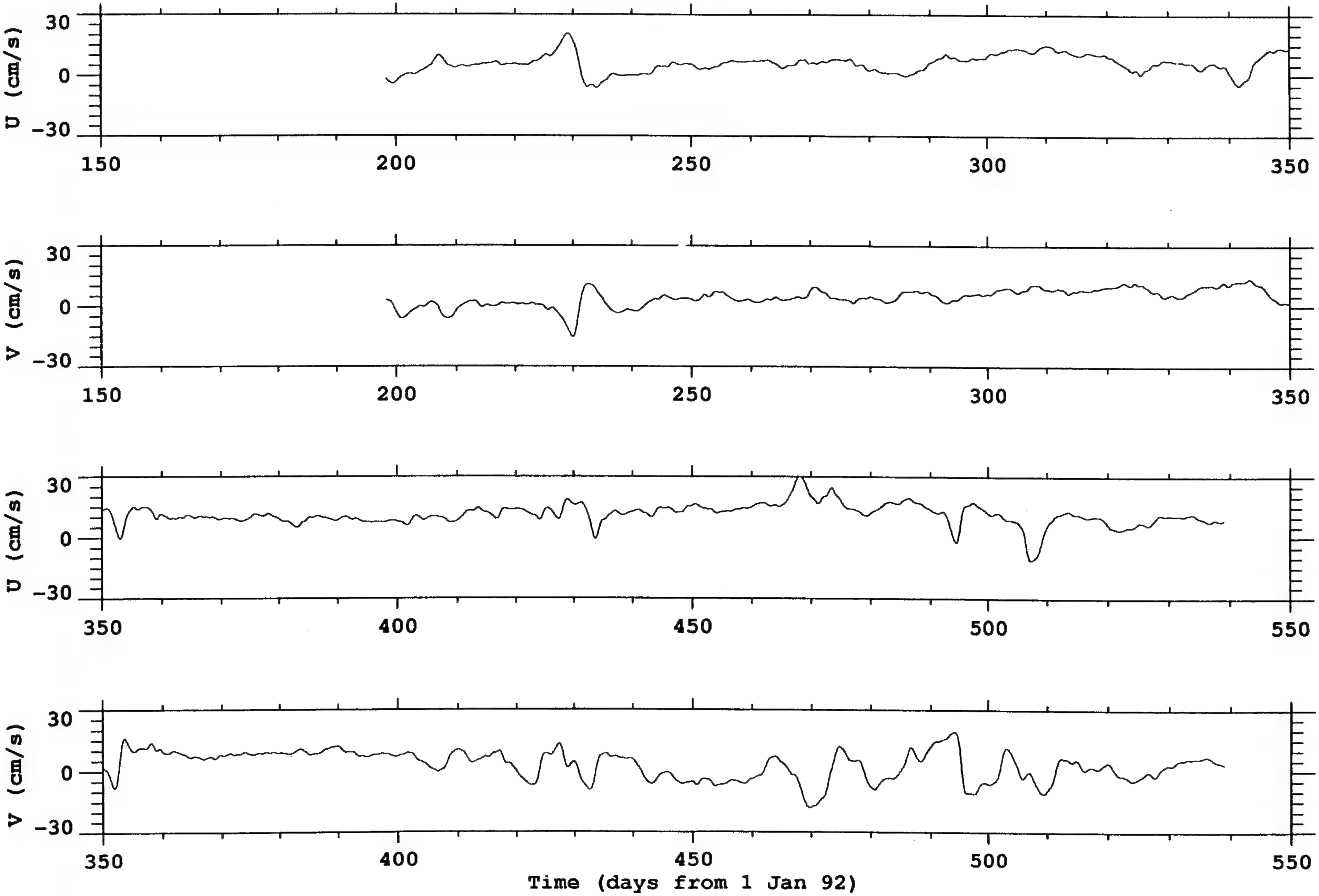
500
550
V (cm/s)
80
20
-40
350
400
450
500
550
Time (days from 1 Jan 92)

cm92d2-1p


U (cm/s)
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V (cm/s)
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-30
150
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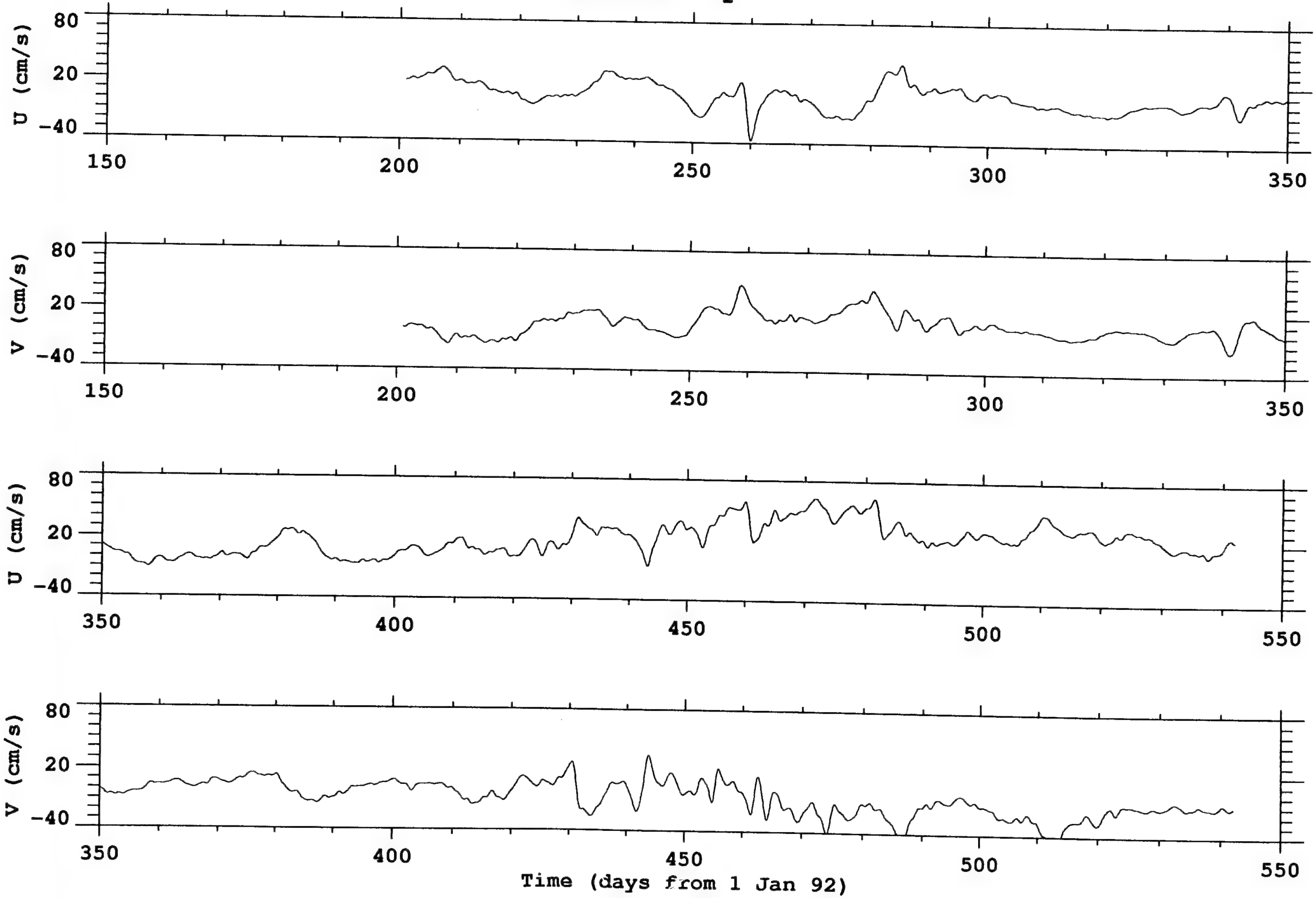
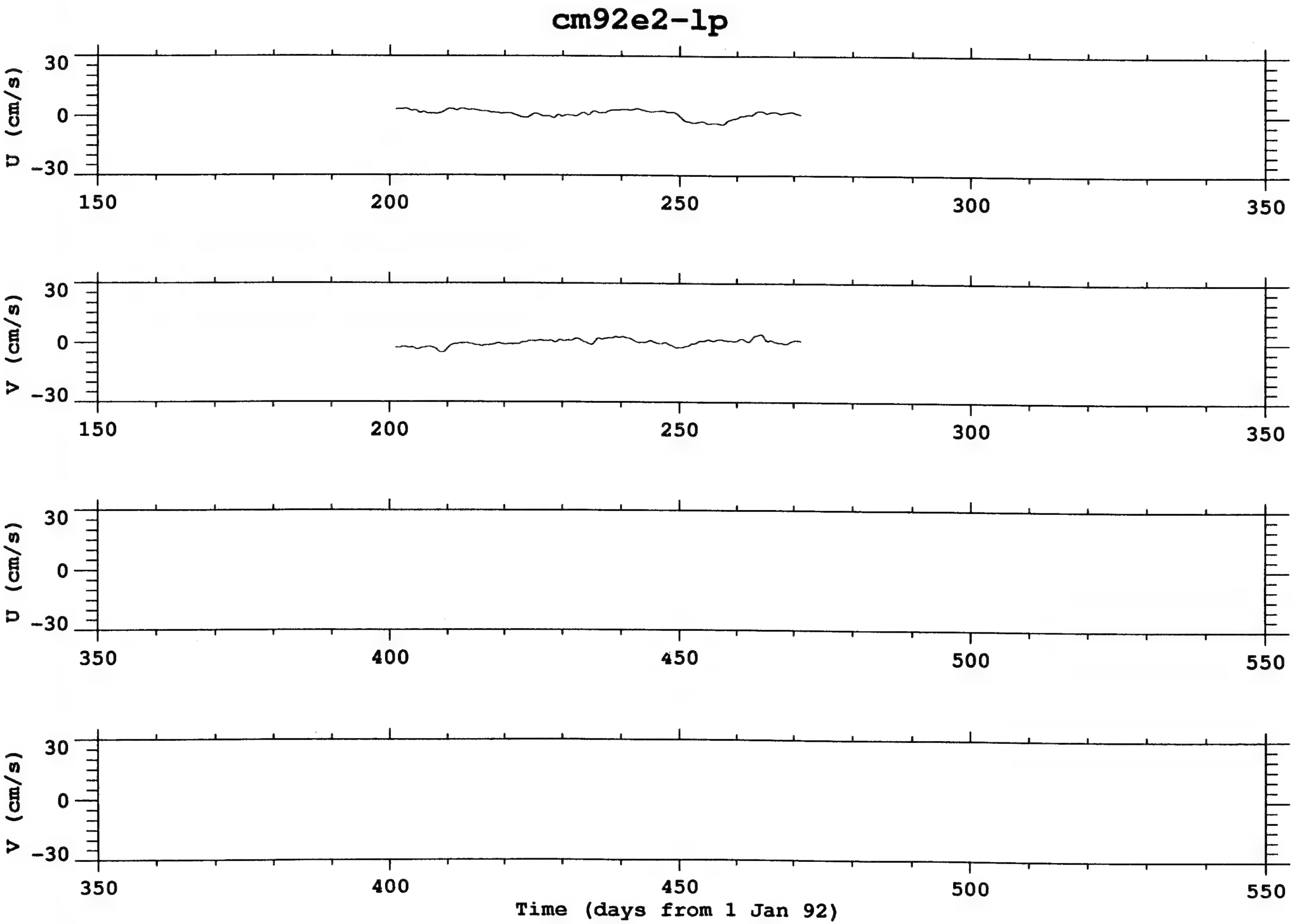
300
350
U (cm/s)
30
0
-30
350
400
450
500
550
V (cm/s)
30
0
-30
350
400
450
500
550
Time (days from 1 Jan 92)

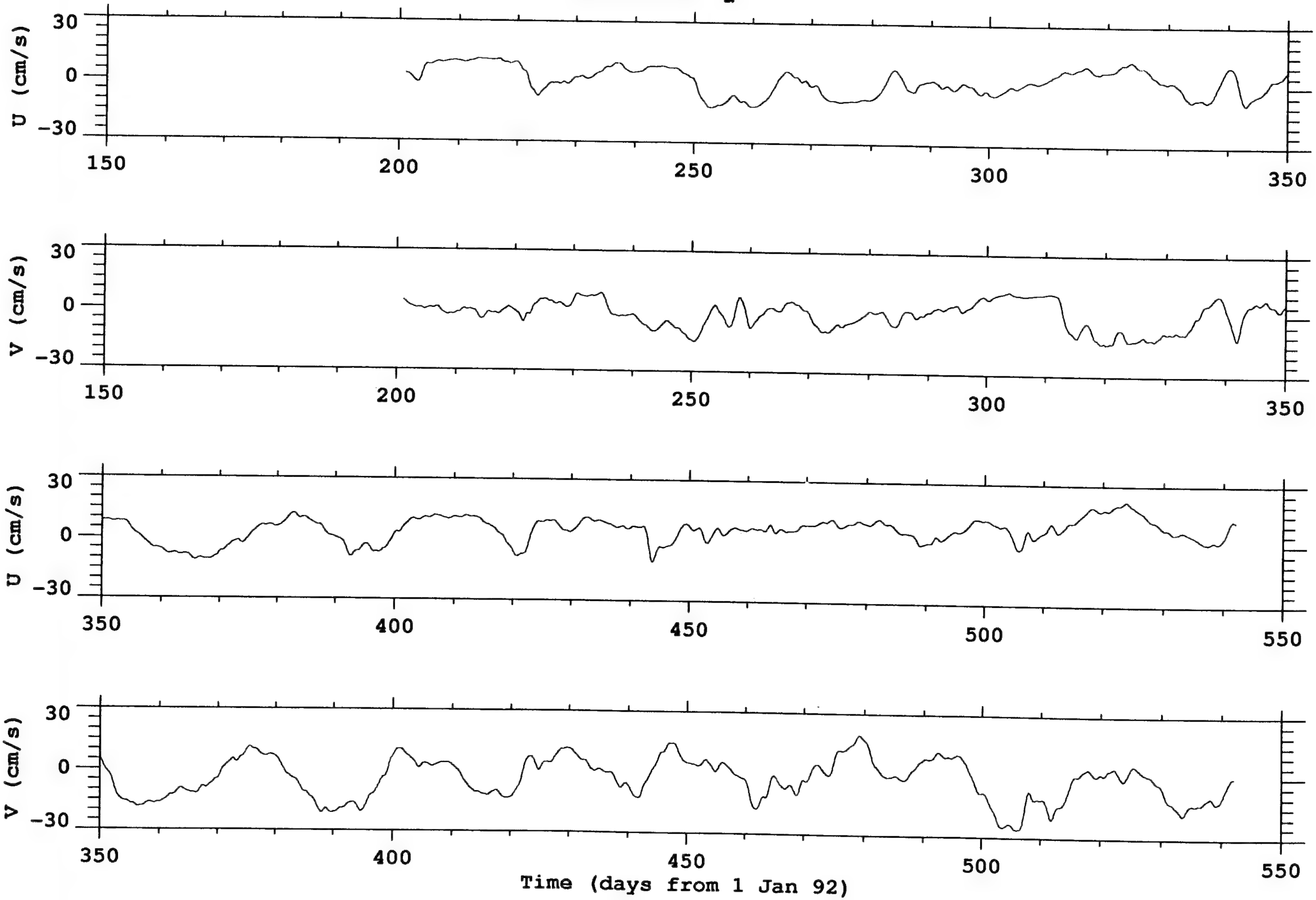
cm92e1-1p



U (cm/s)
80
20
-40
150
200
250
300
350
V (cm/s)
80
20
-40
150
200
250
300
350
U (cm/s)
80
20
-40
350
400
450
500
550
V (cm/s)
80
20
-40
350
400
450
500
550
Time (days from 1 Jan 92)

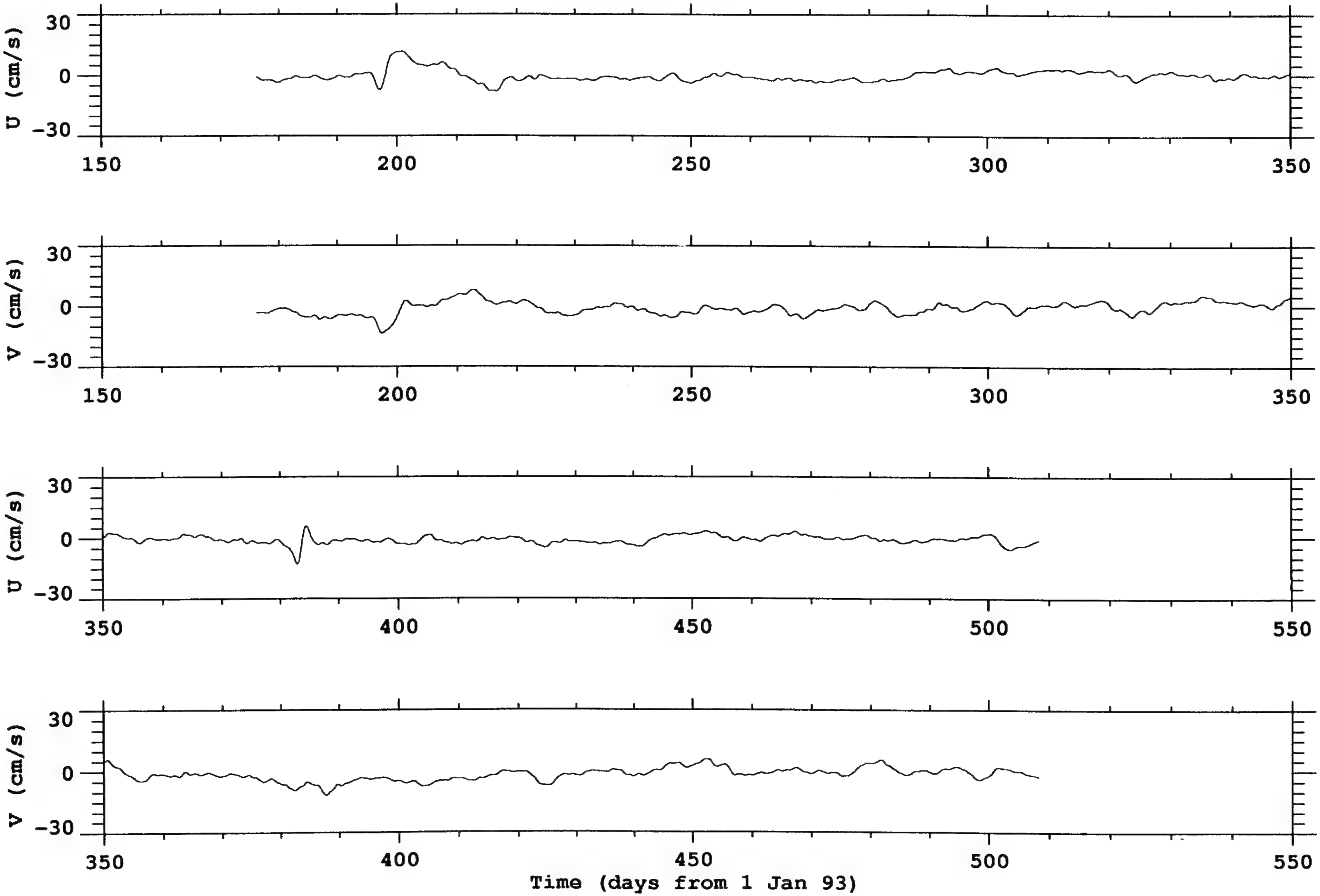

cm92e2-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92e4-1p



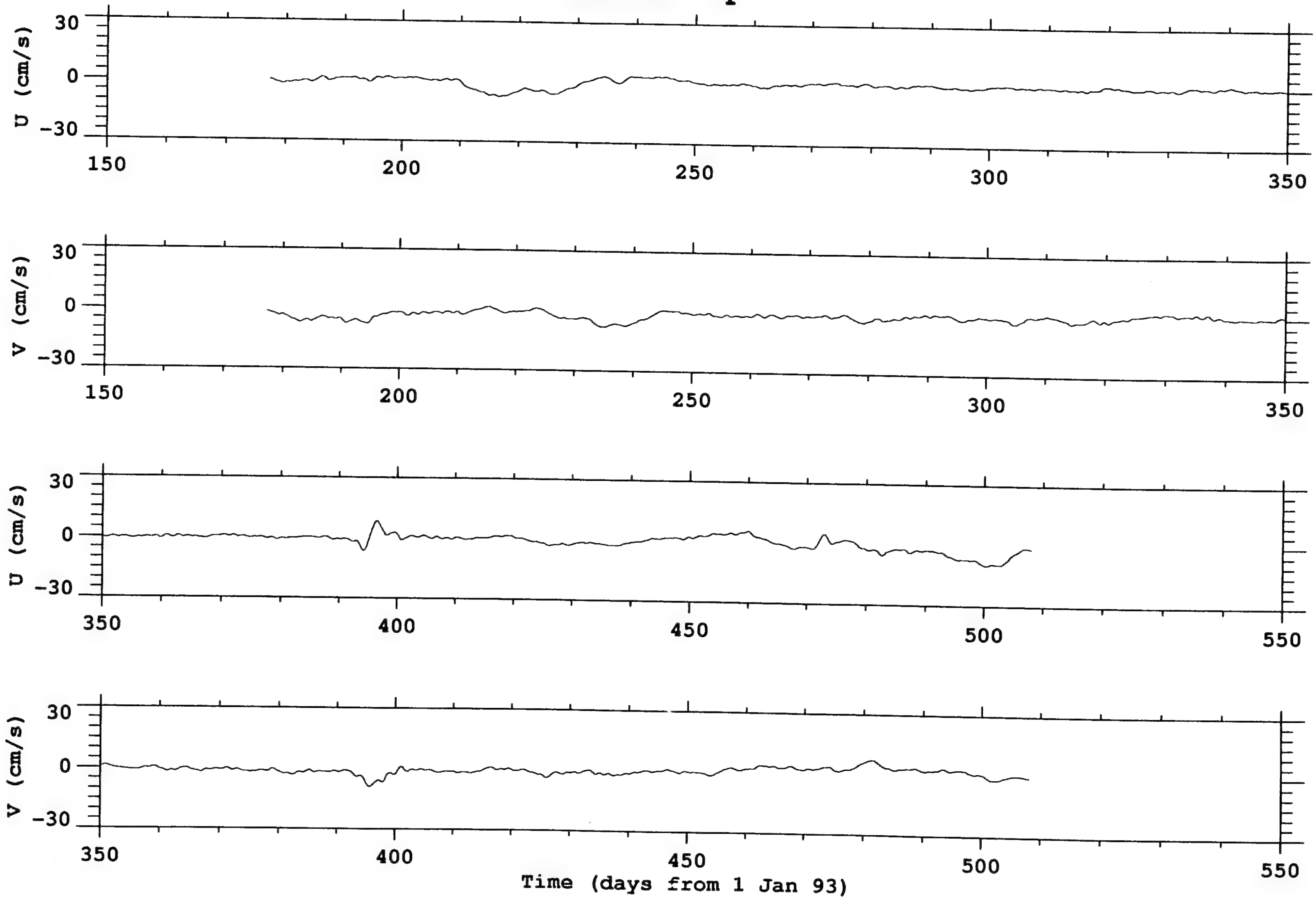
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm93b1-1p

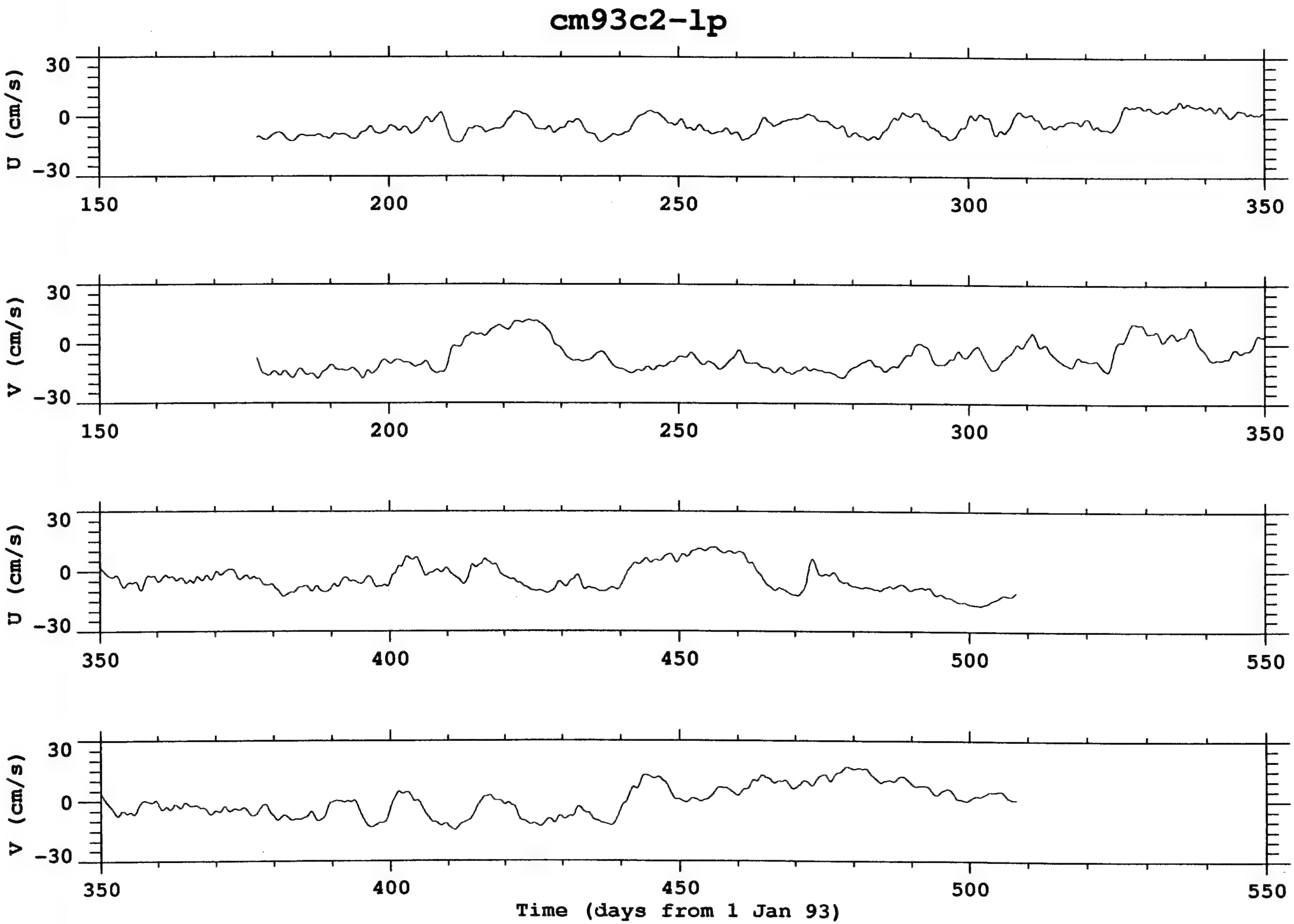


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

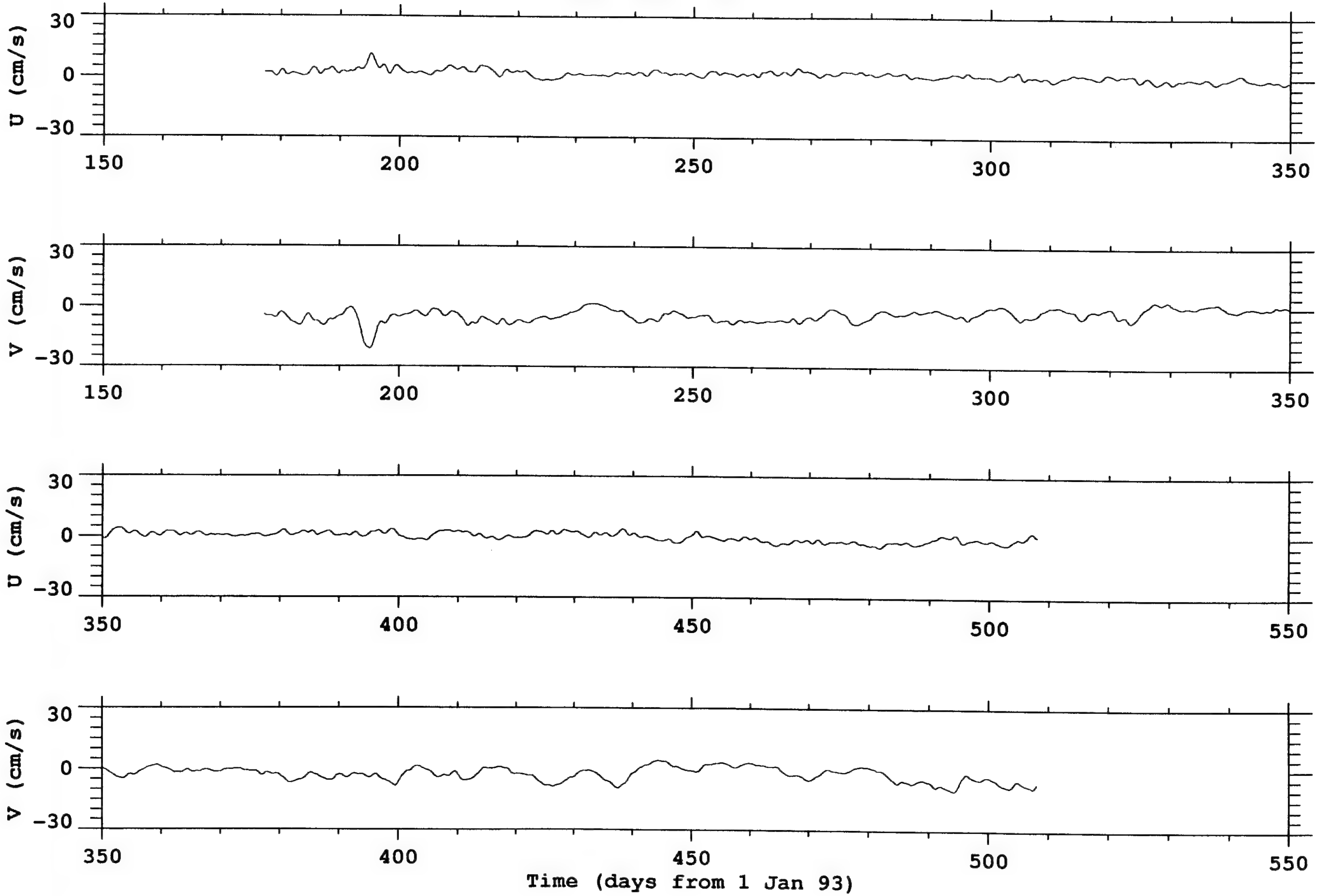
cm93c1-1p



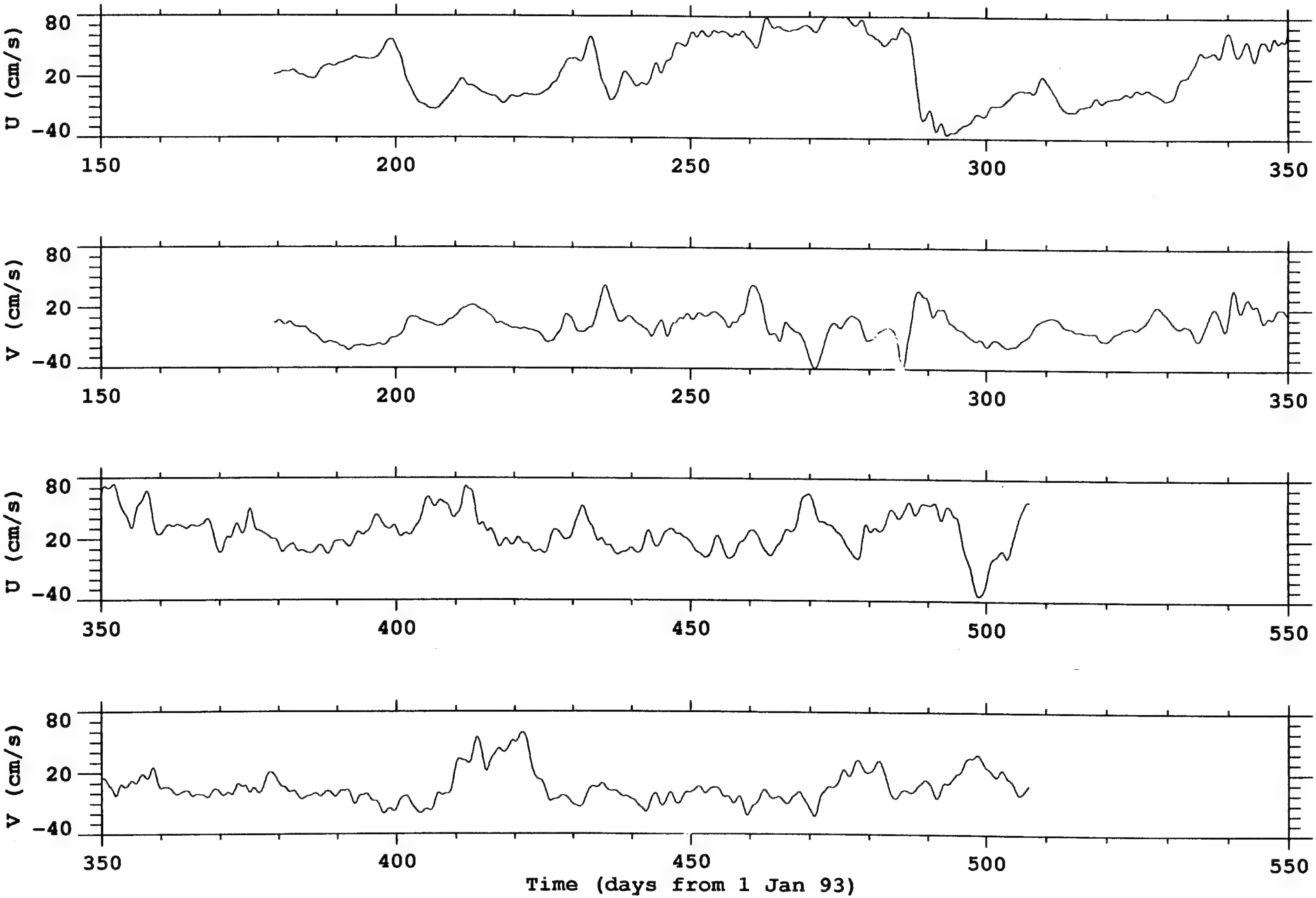
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)


cm93c2-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

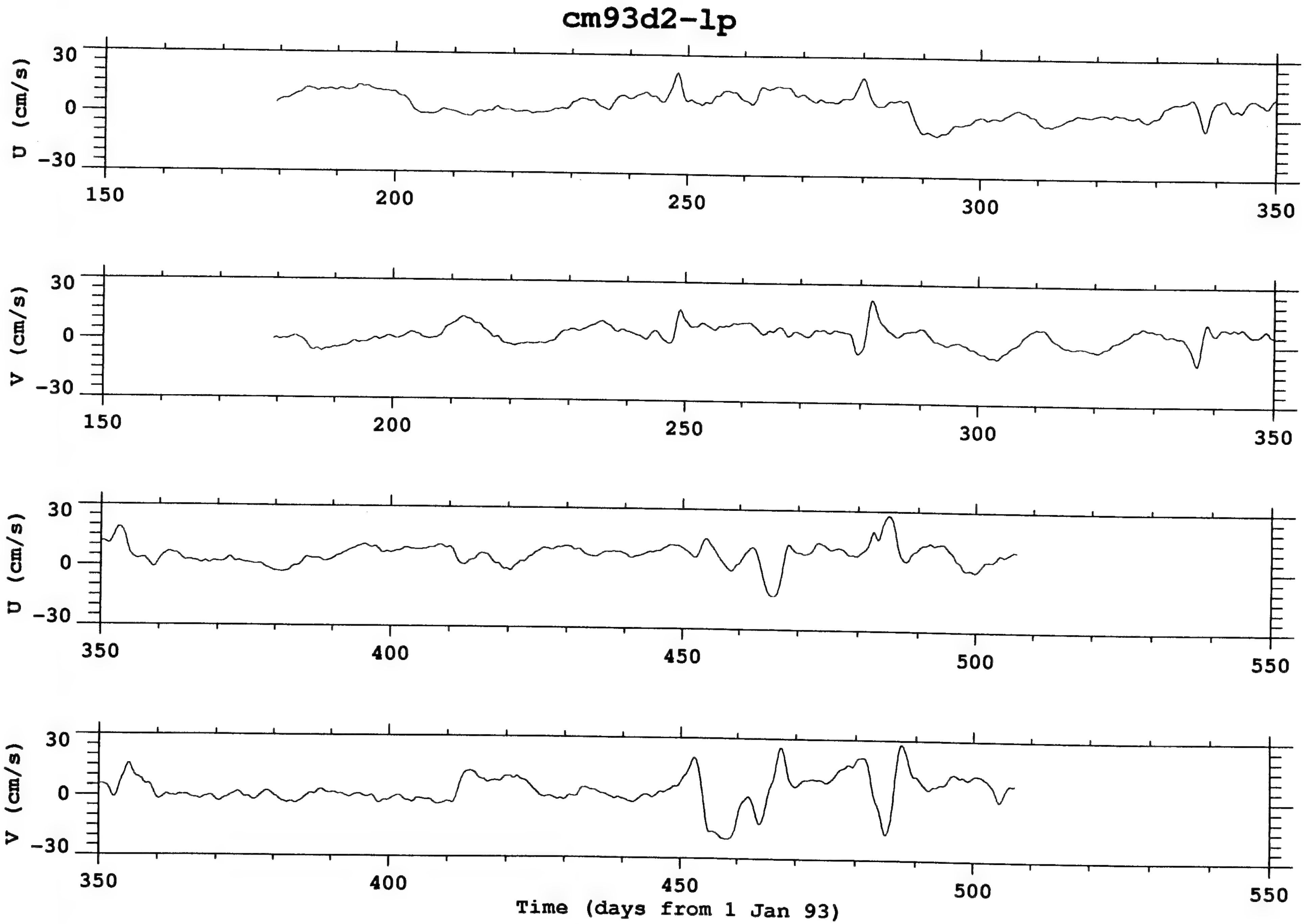
cm93c3-1p


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

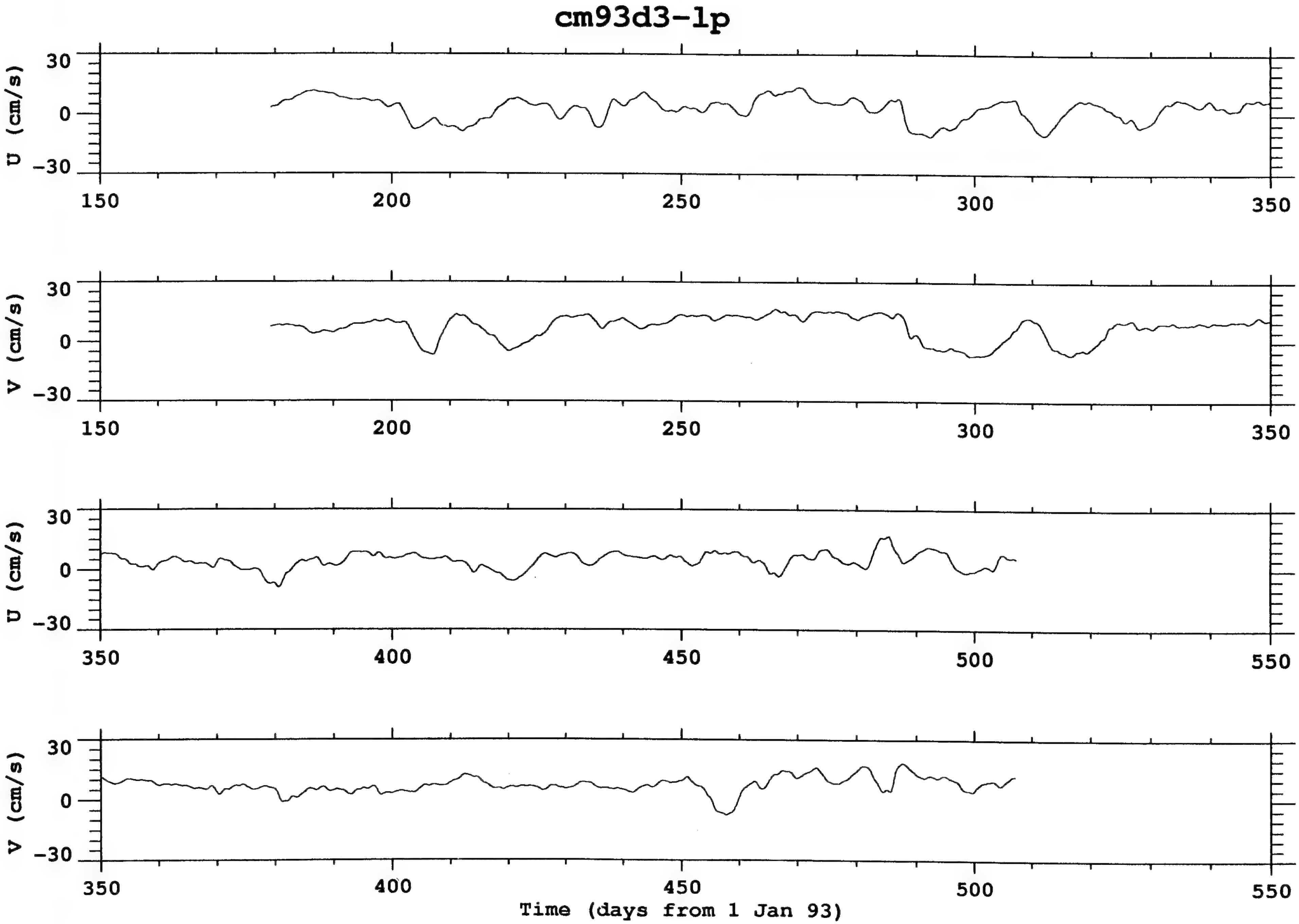
cm93d1-1p



U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
80
20
-40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

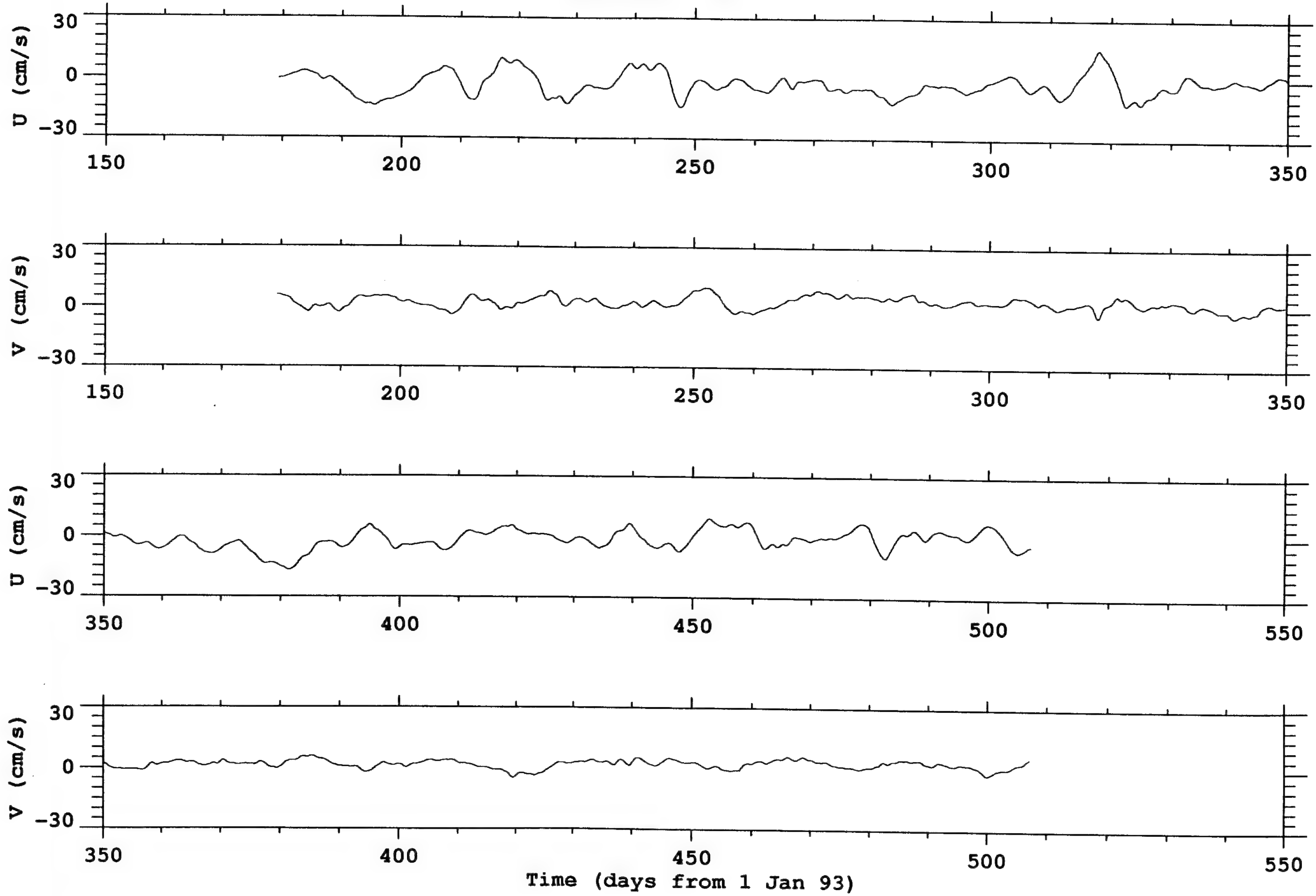


cm93d2-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)



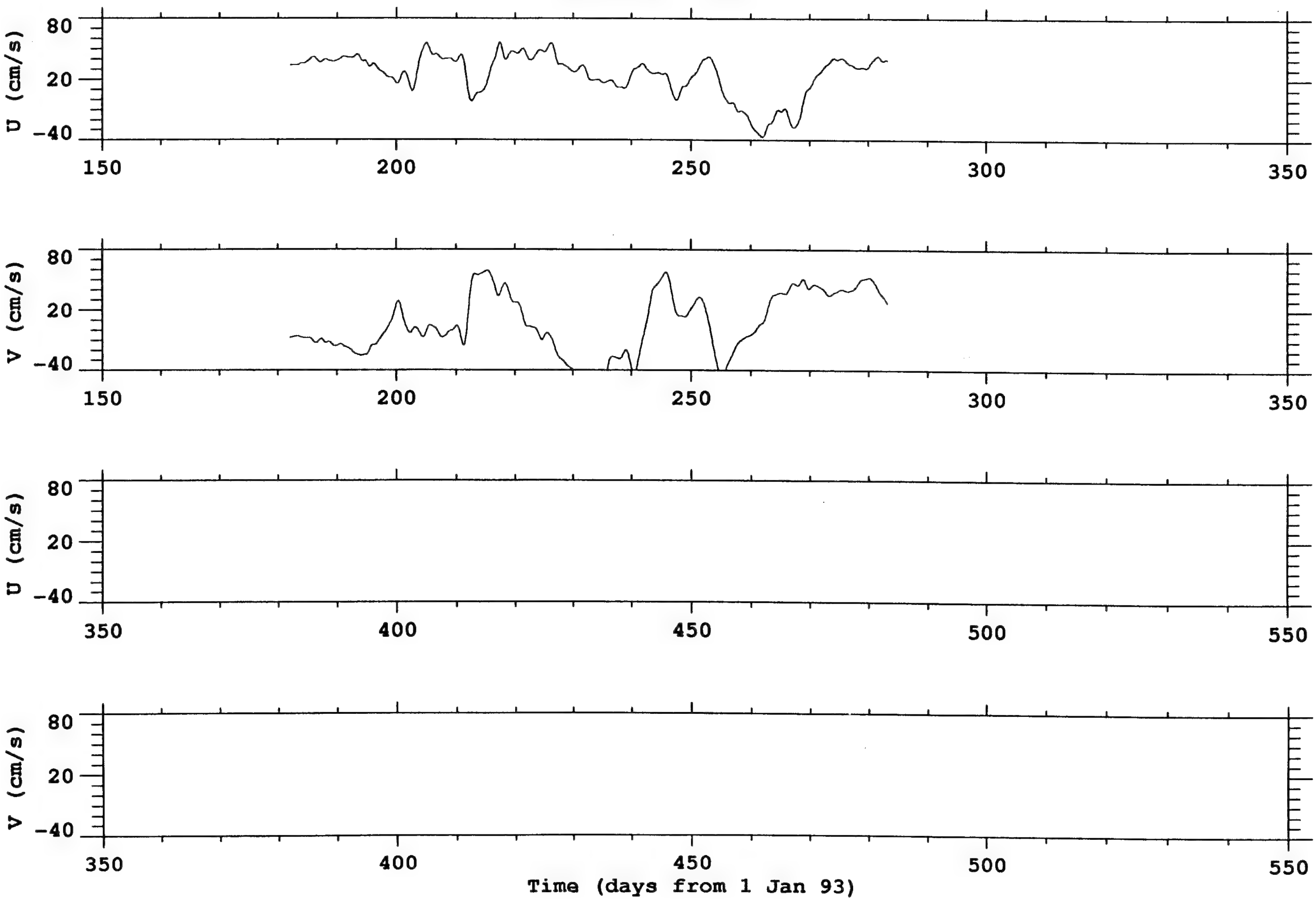
cm93d3-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

cm93d4-1p

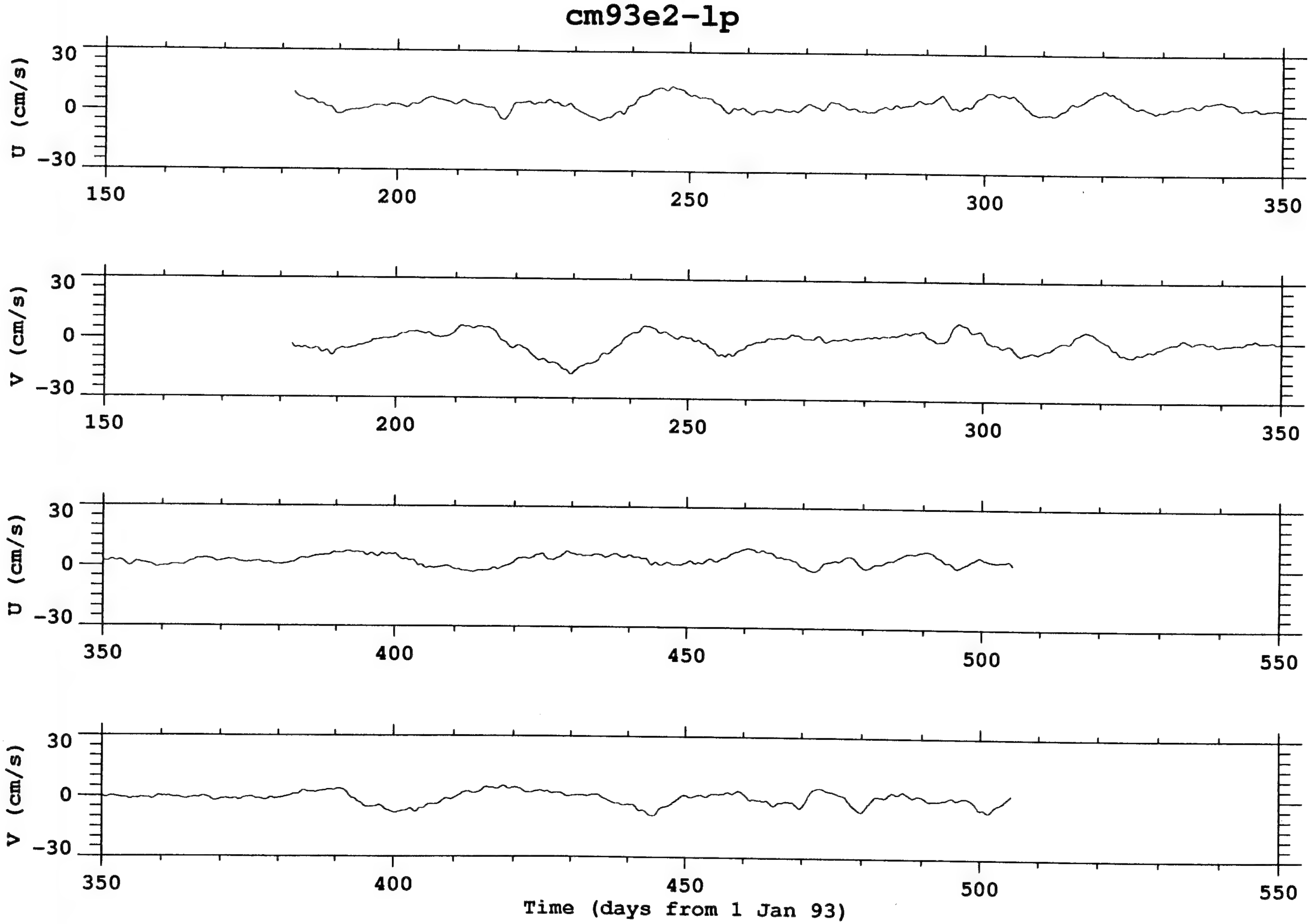


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

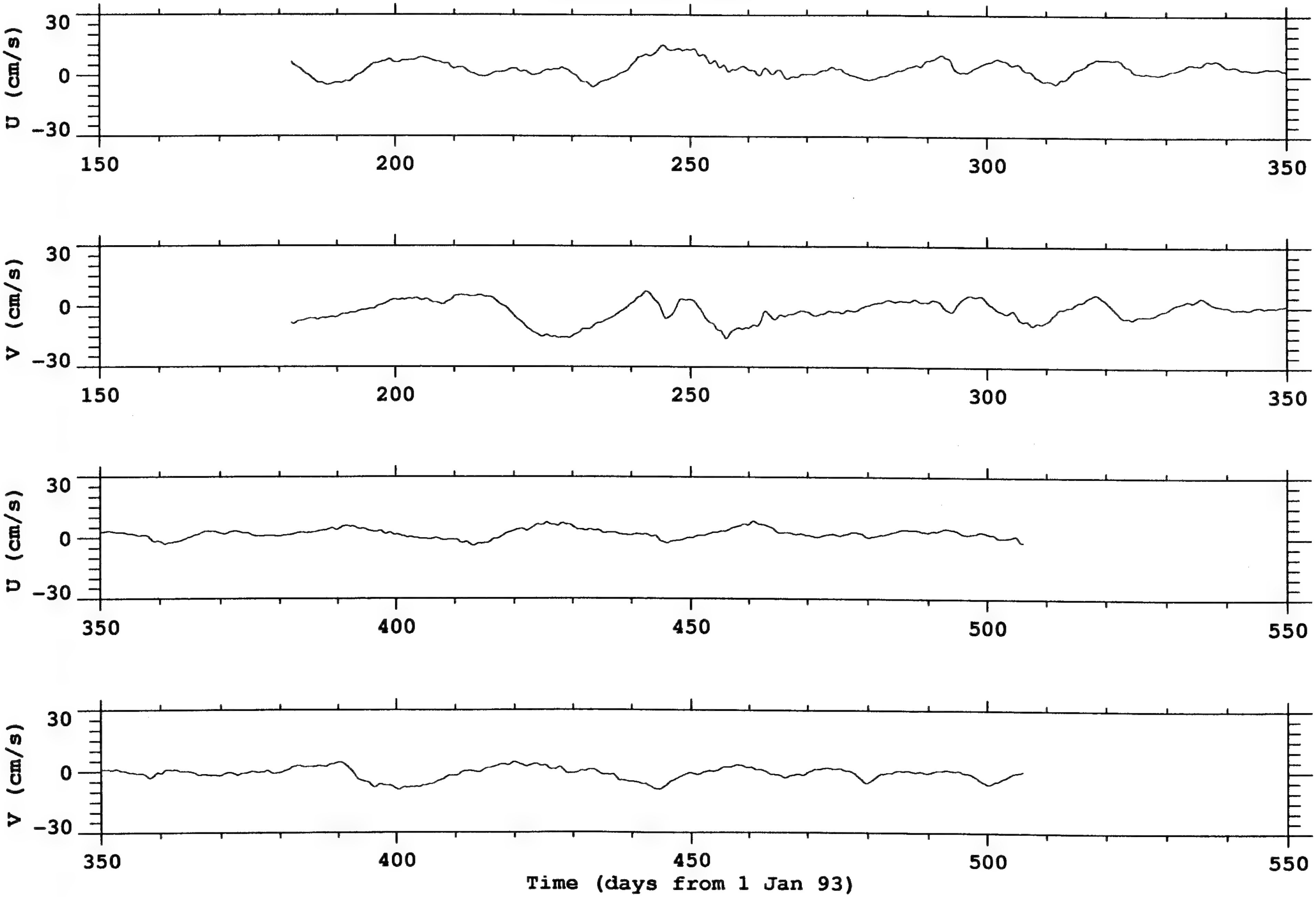
cm93e1-1p



U (cm/s)
80
20
-40
150
200
250
300
350
V (cm/s)
80
20
-40
150
200
250
300
350
U (cm/s)
80
20
-40
350
400
450
500
550
V (cm/s)
80
20
-40
350
400
450
500
550
Time (days from 1 Jan 93)

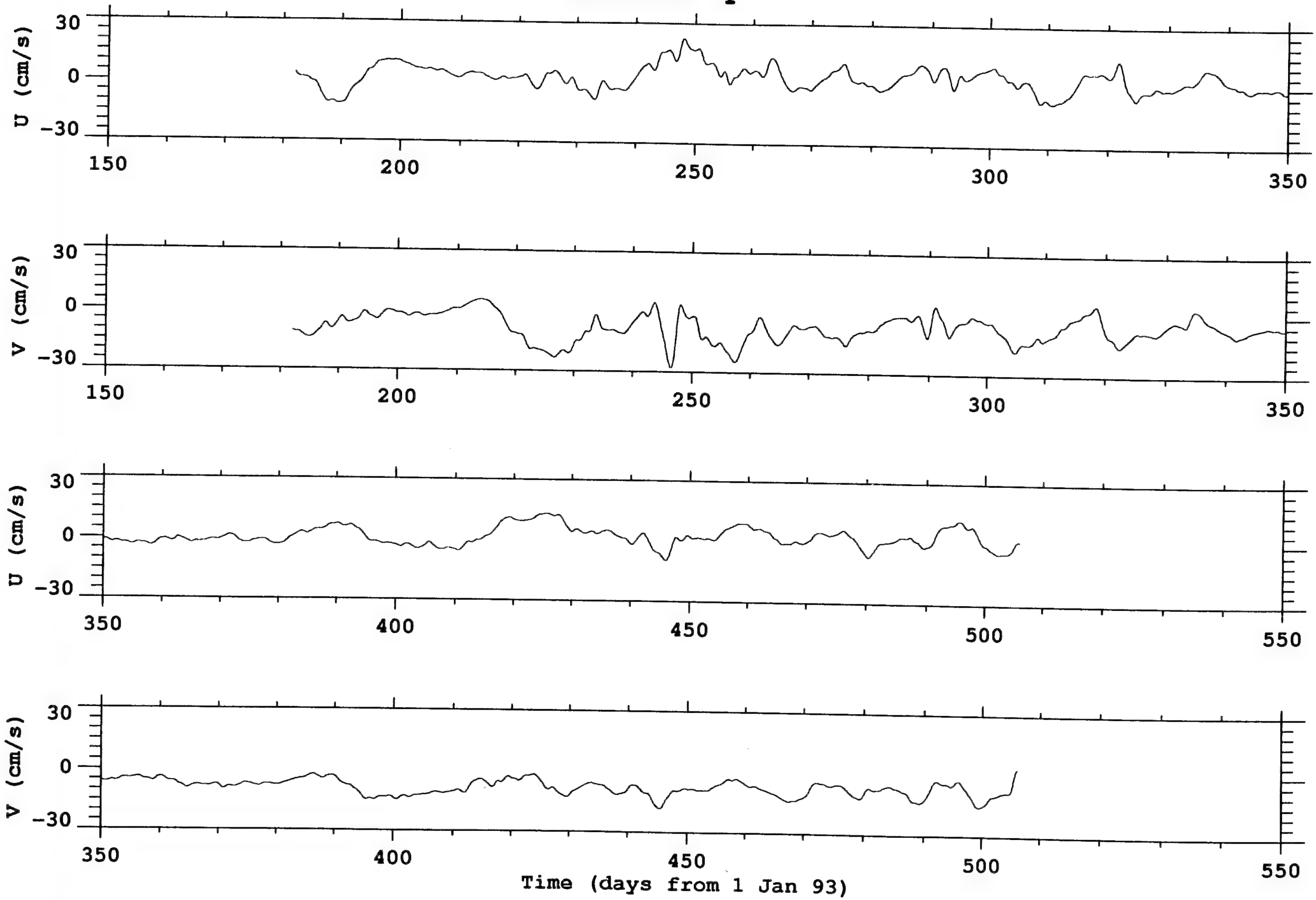

cm93e2-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

cm93e3-1p



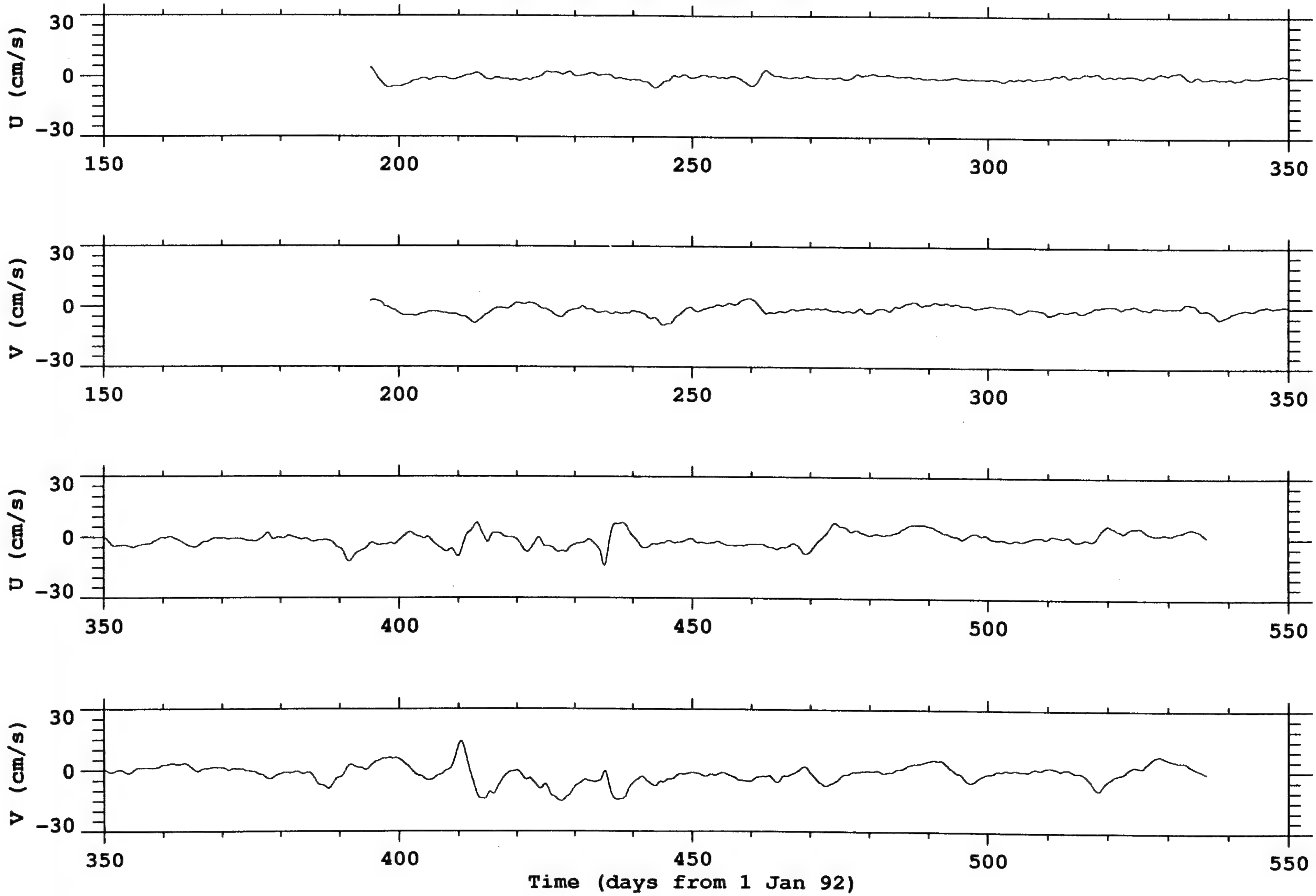
U (cm/s)
30
0
-30
150
200
250
300
350
V (cm/s)
30
0
-30
150
200
250
300
350
U (cm/s)
30
0
-30
350
400
450
500
550
V (cm/s)
30
0
-30
350
400
450
500
550
Time (days from 1 Jan 93)

cm93e4-1p

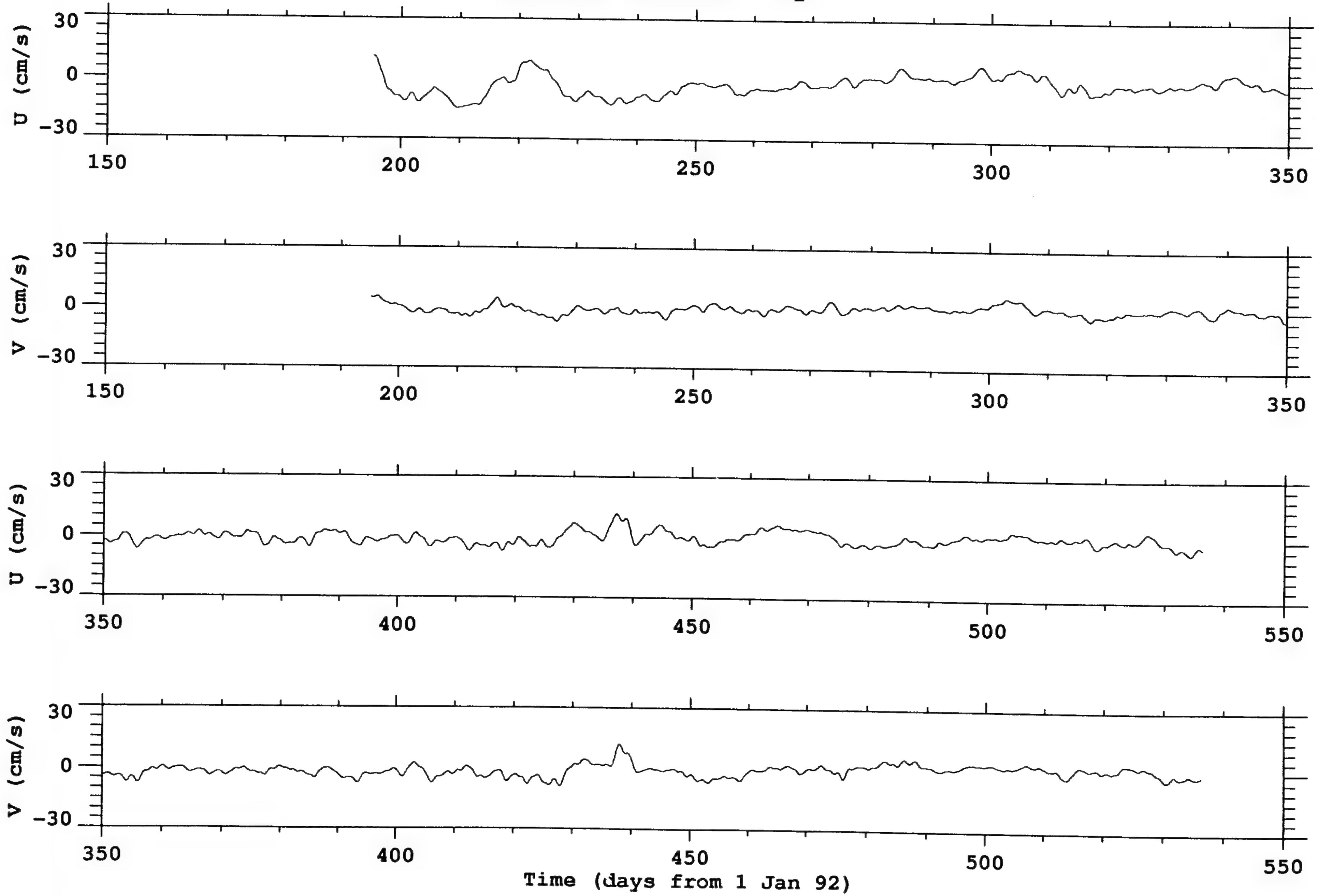


U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

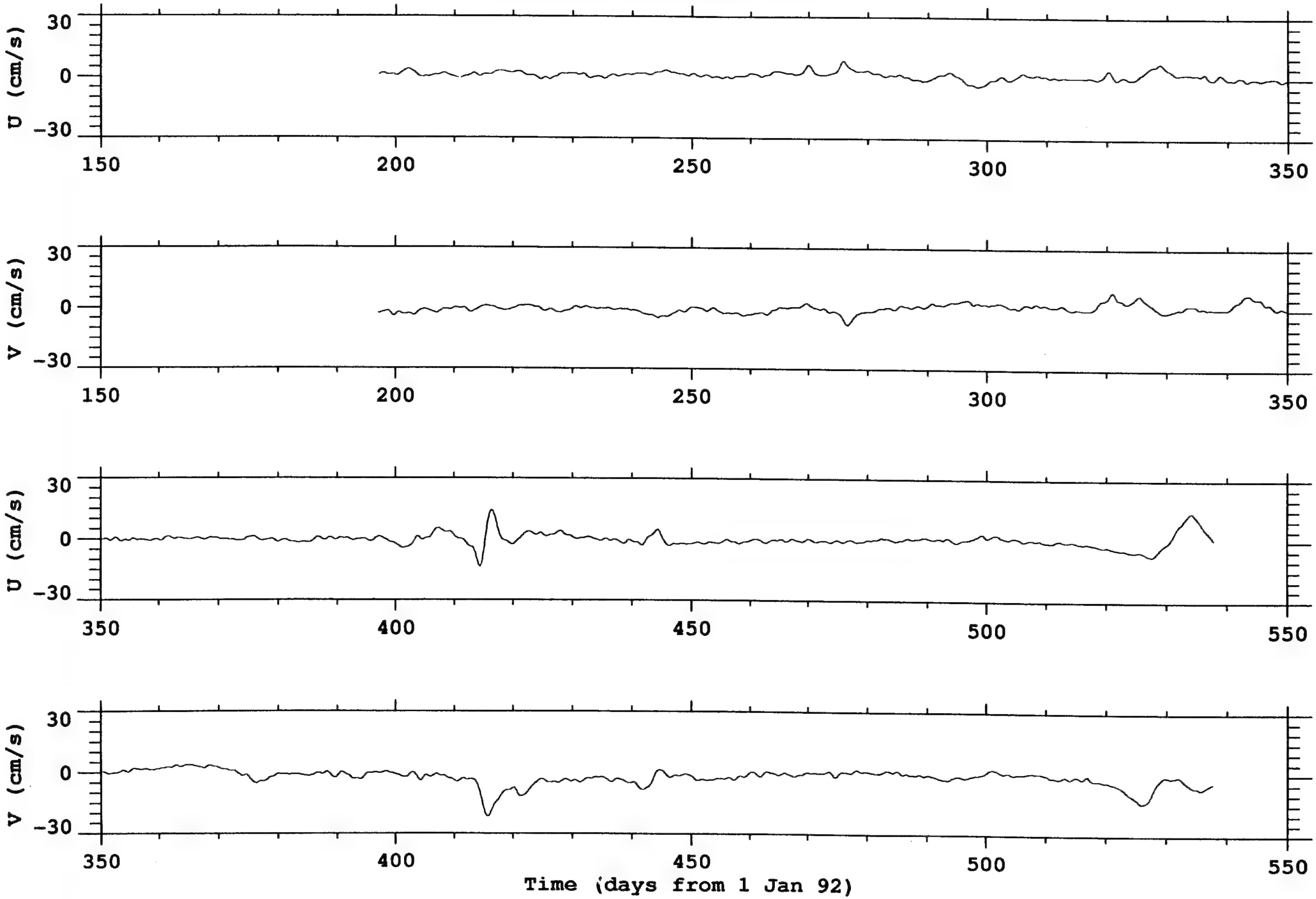
cm92b1-offset-lp



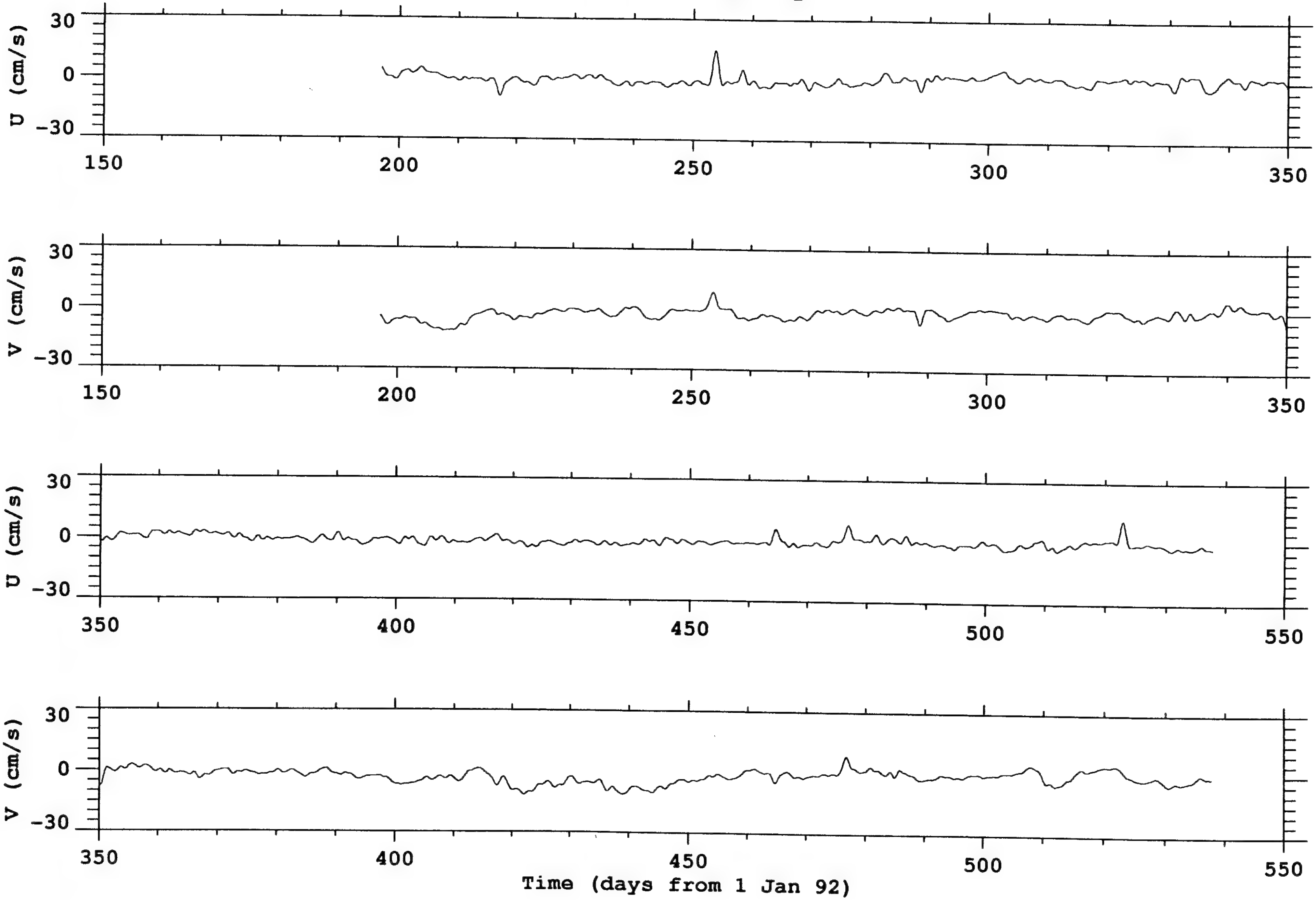
cm92b2-offset-1p



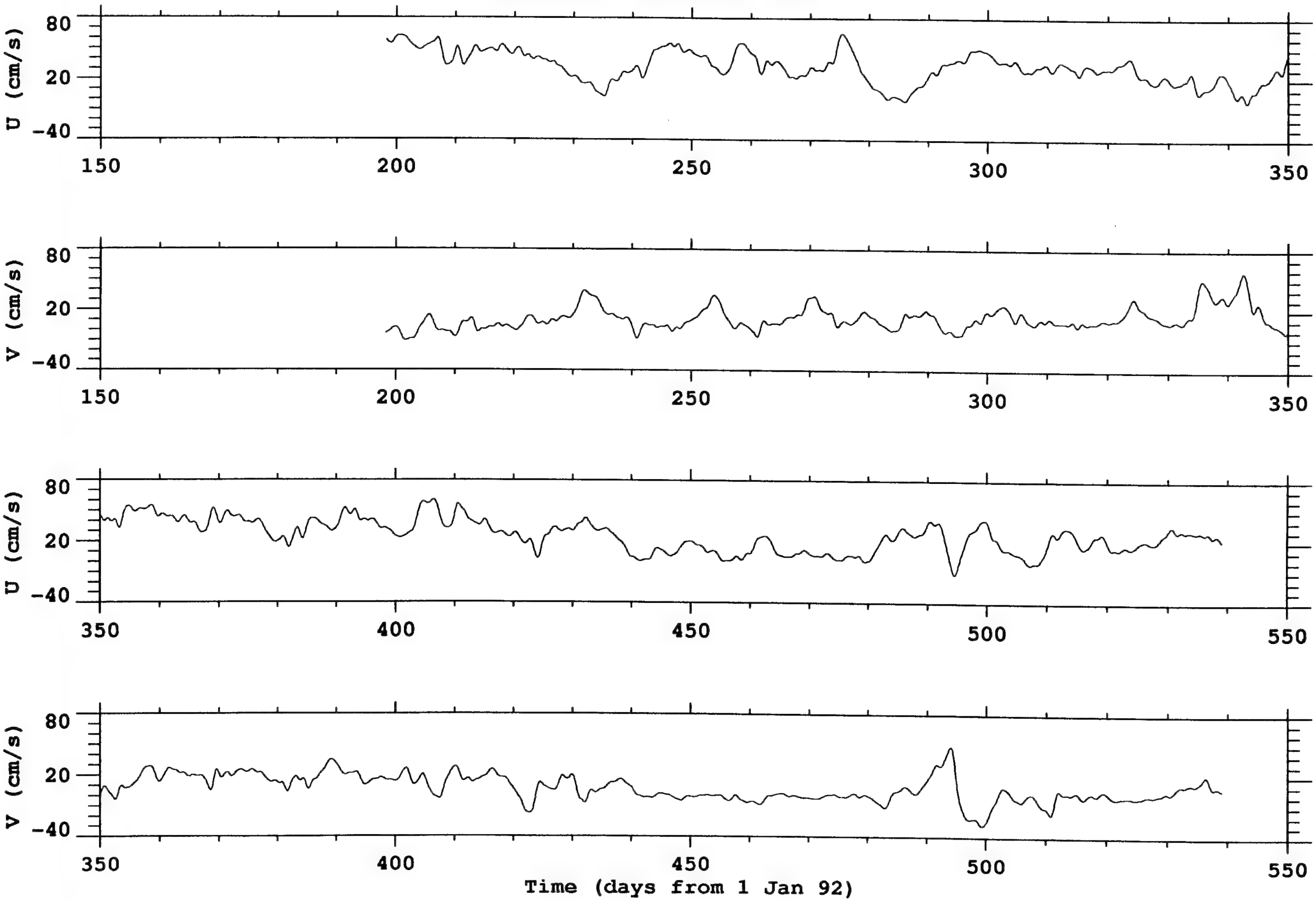
cm92c1-offset-lp



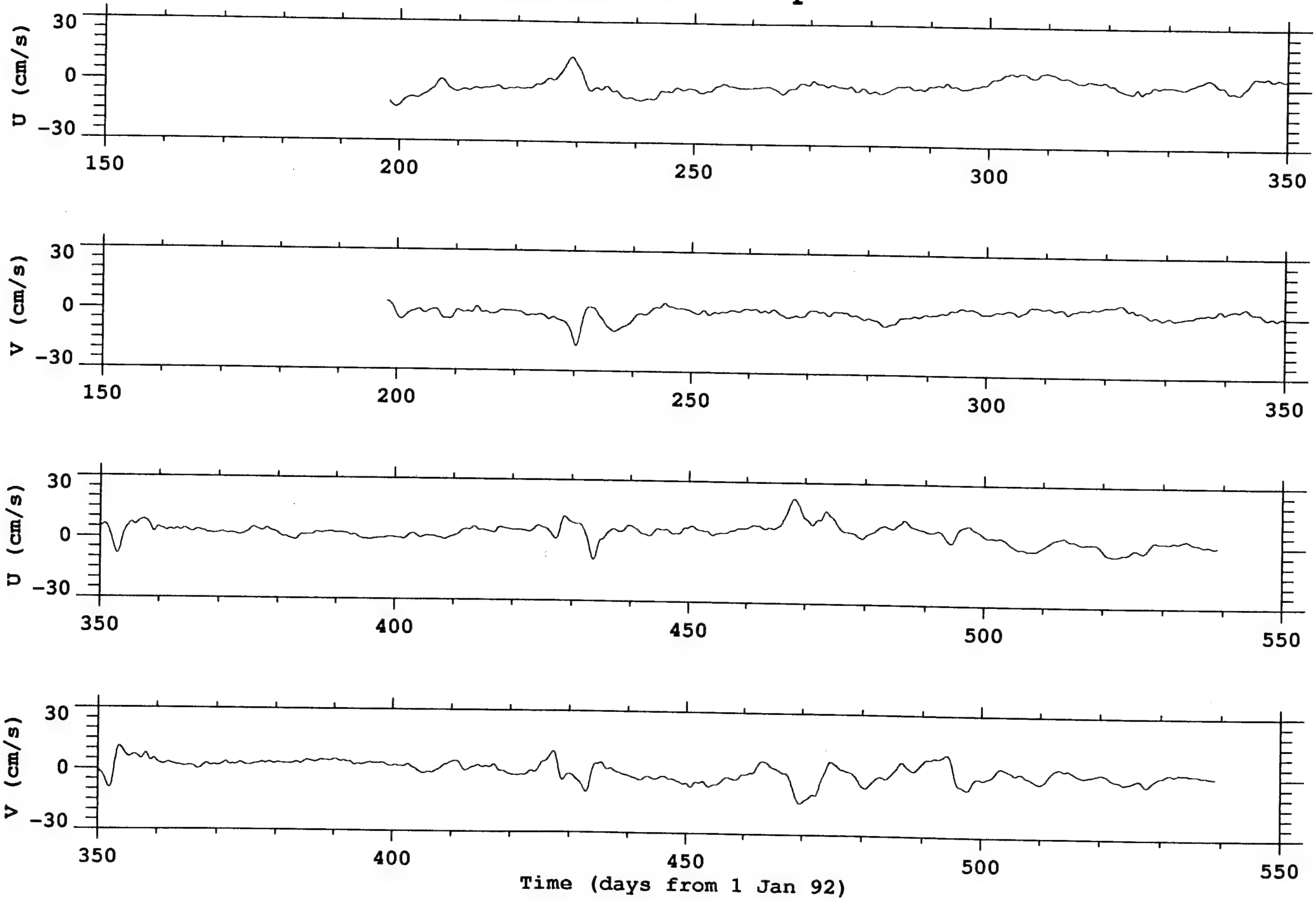
cm92c3-offset-1p

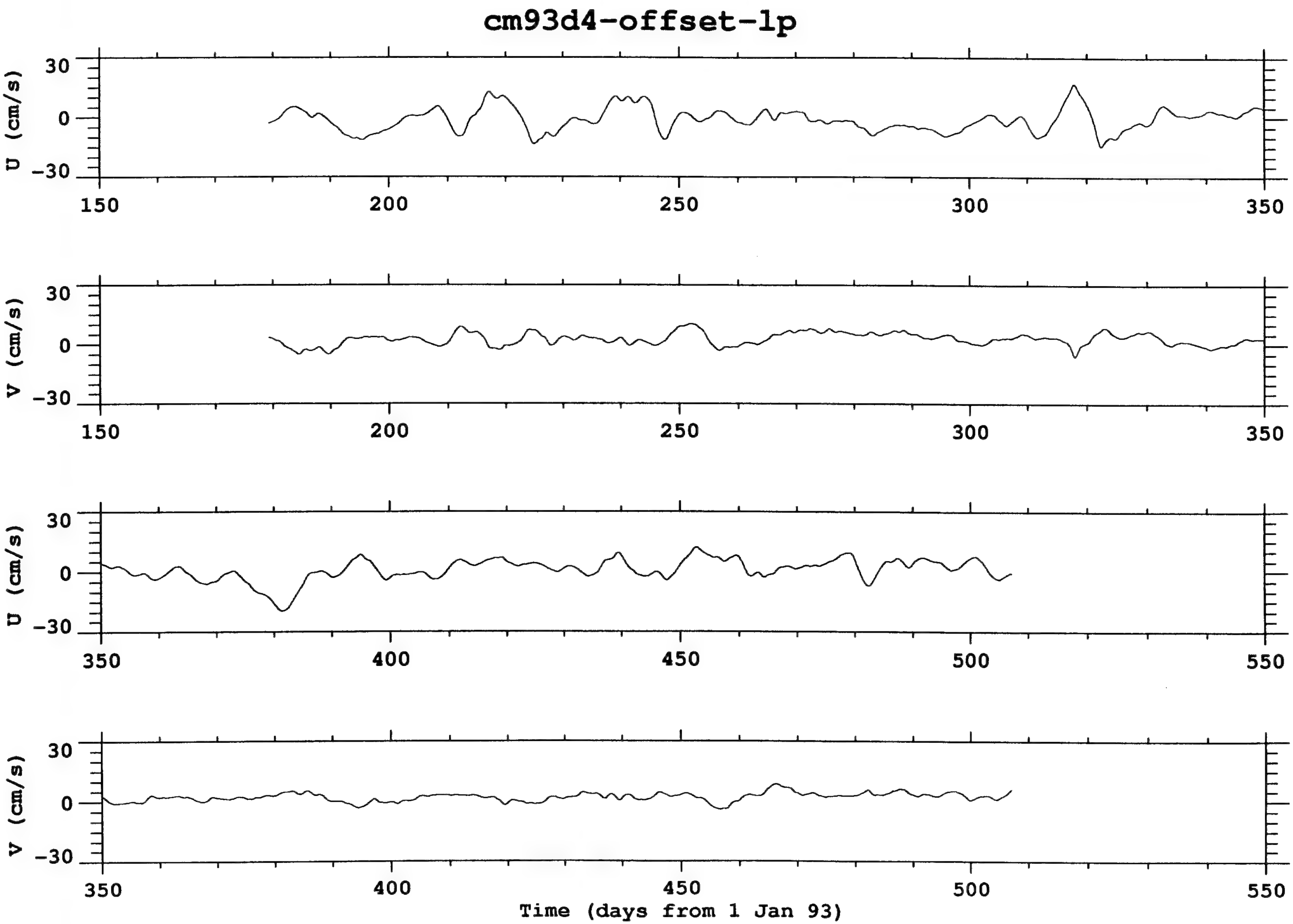


cm92d1-offset-lp

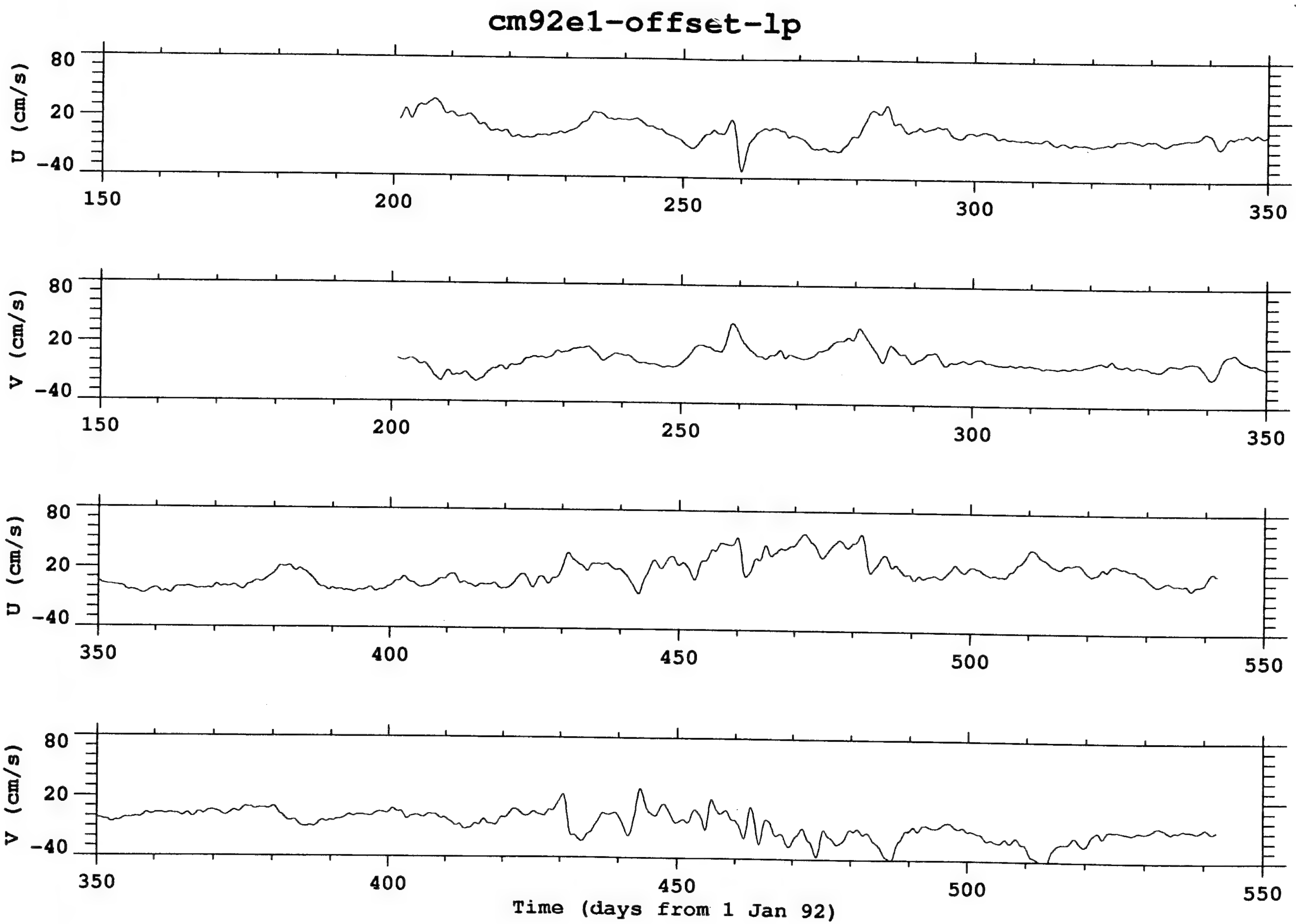


cm92d2-offset-1p

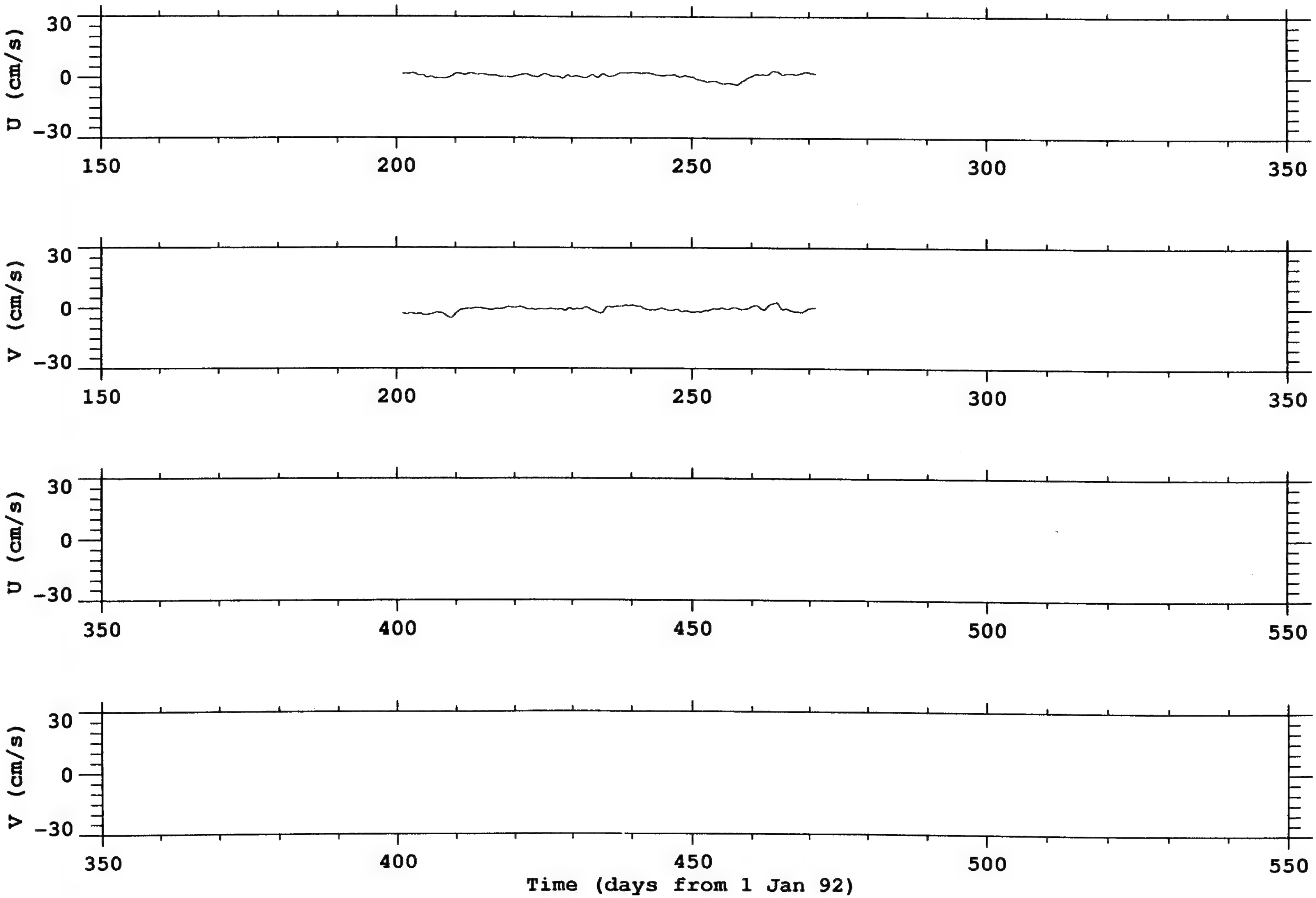




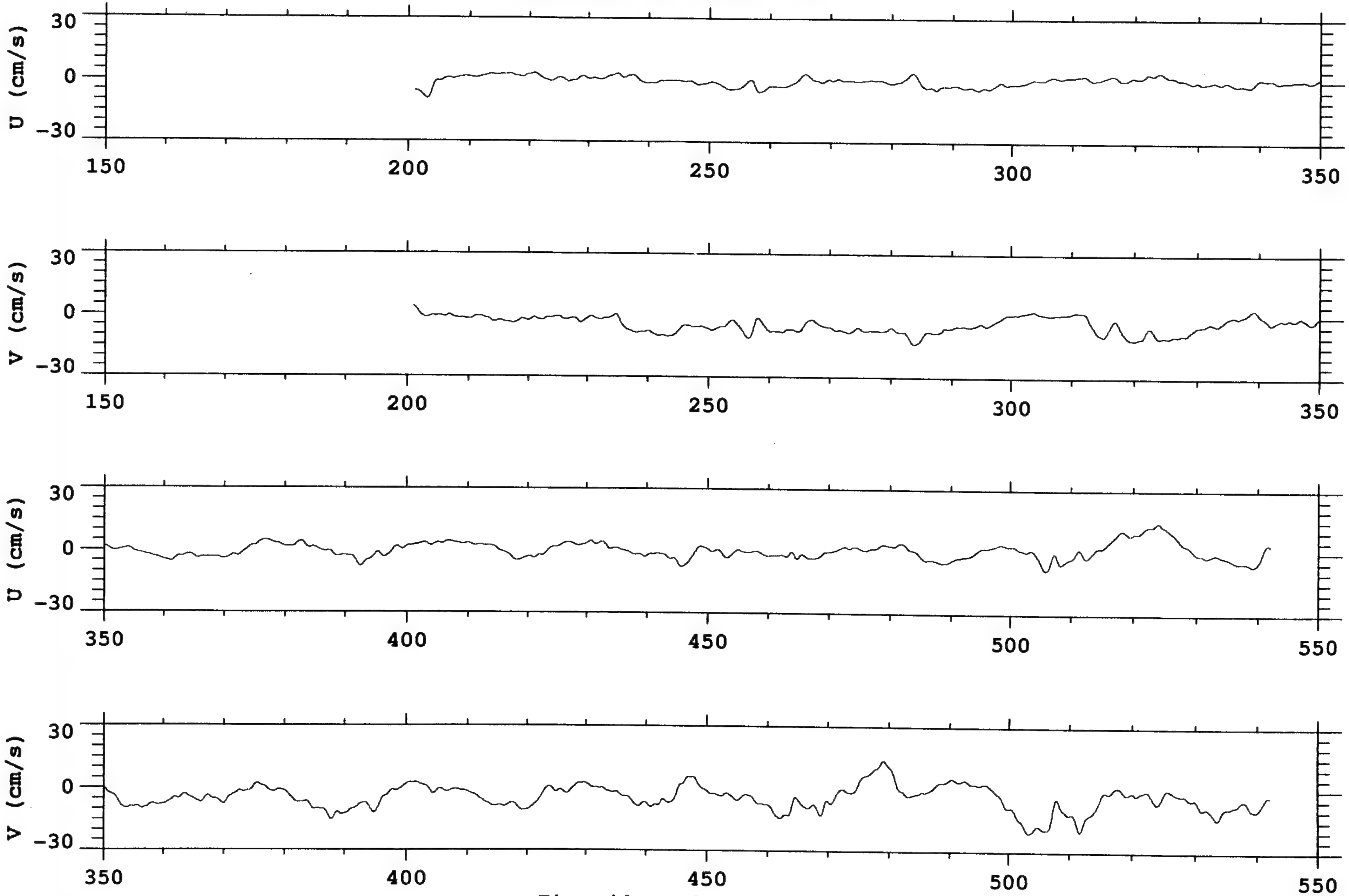
cm93d4-offset-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
-30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)


cm92e1-offset-1p
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
80
20
-40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 92)

cm92e2-offset-1p

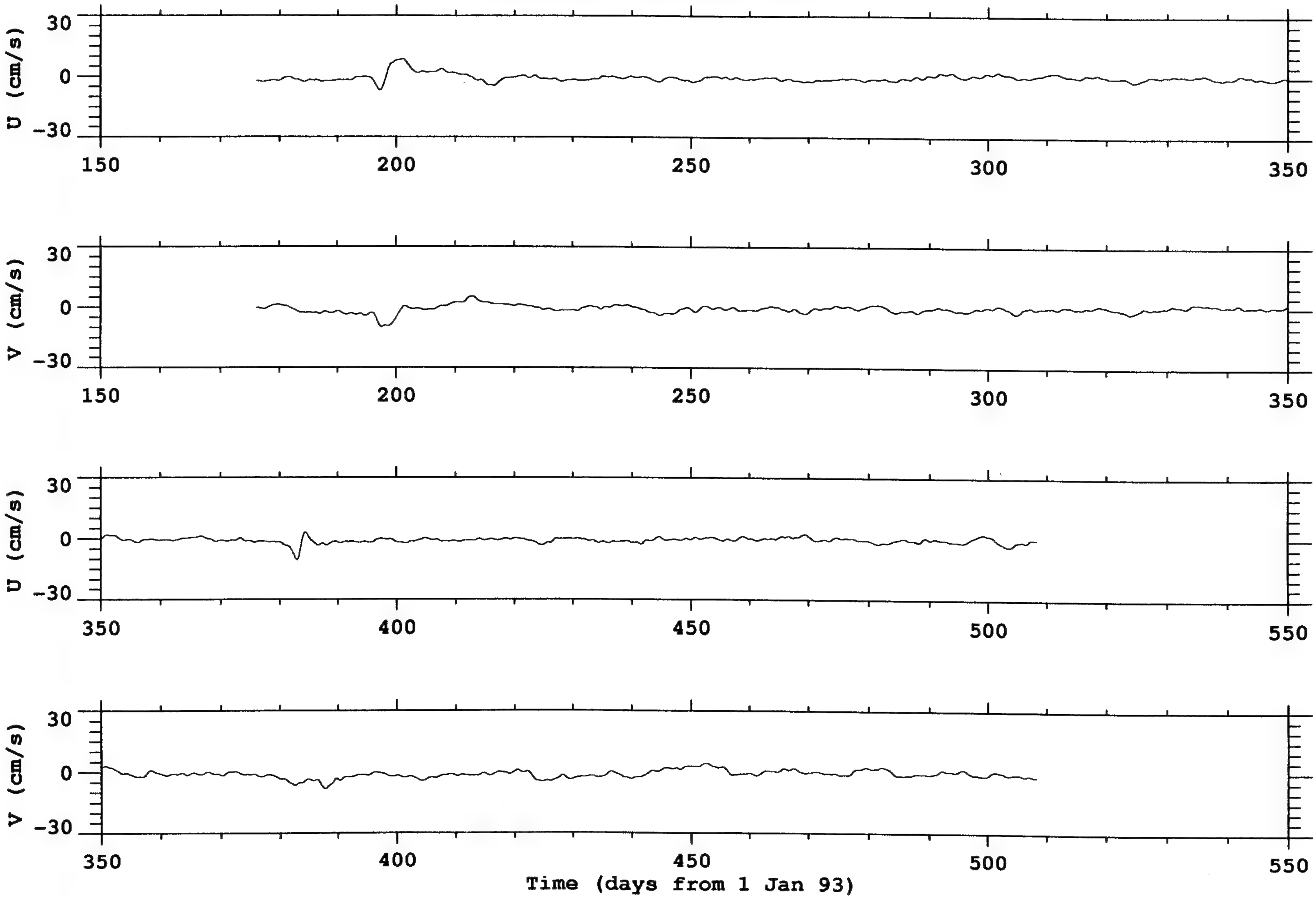


cm92e4-offset-lp

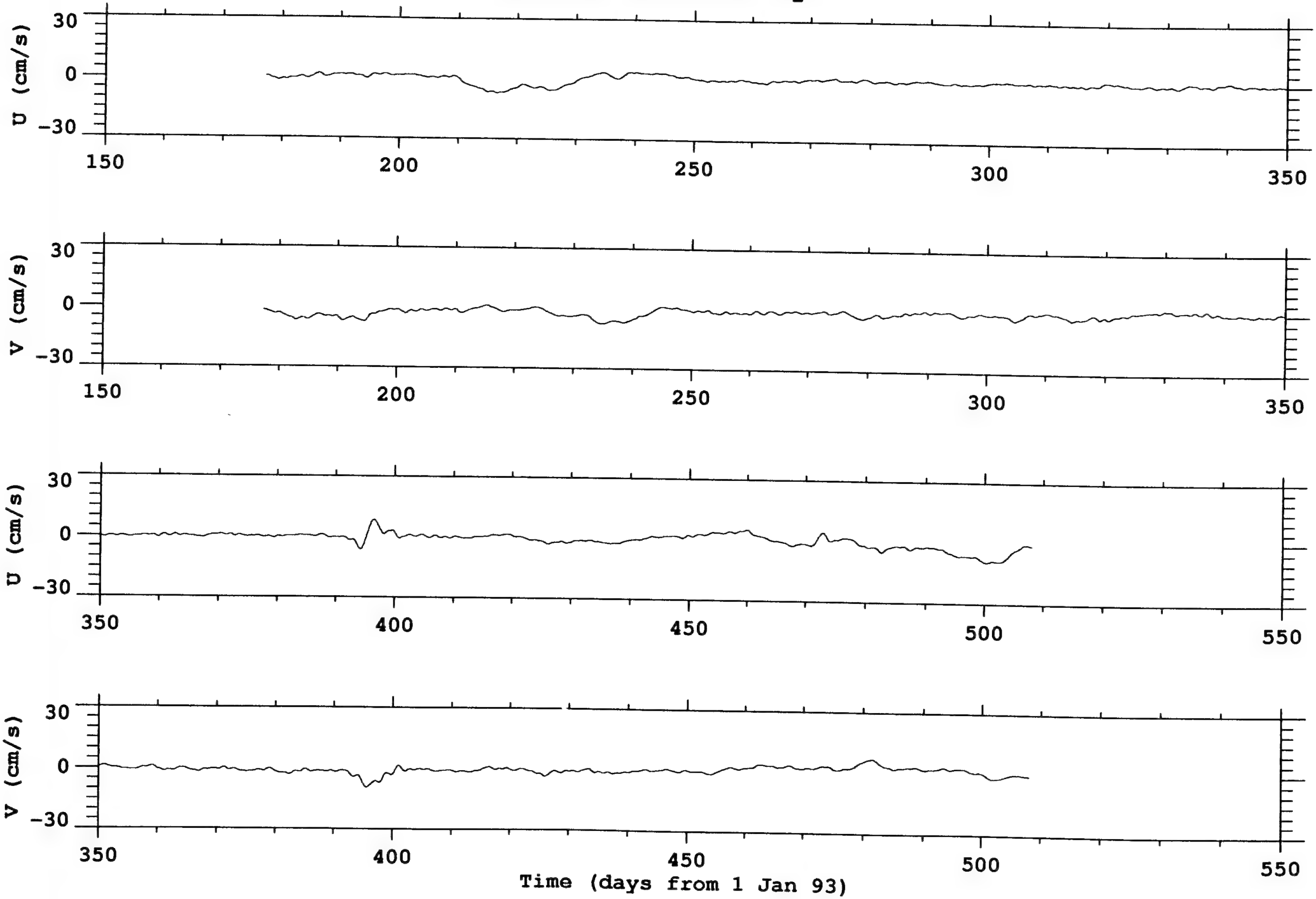


Time (days from 1 Jan 92)

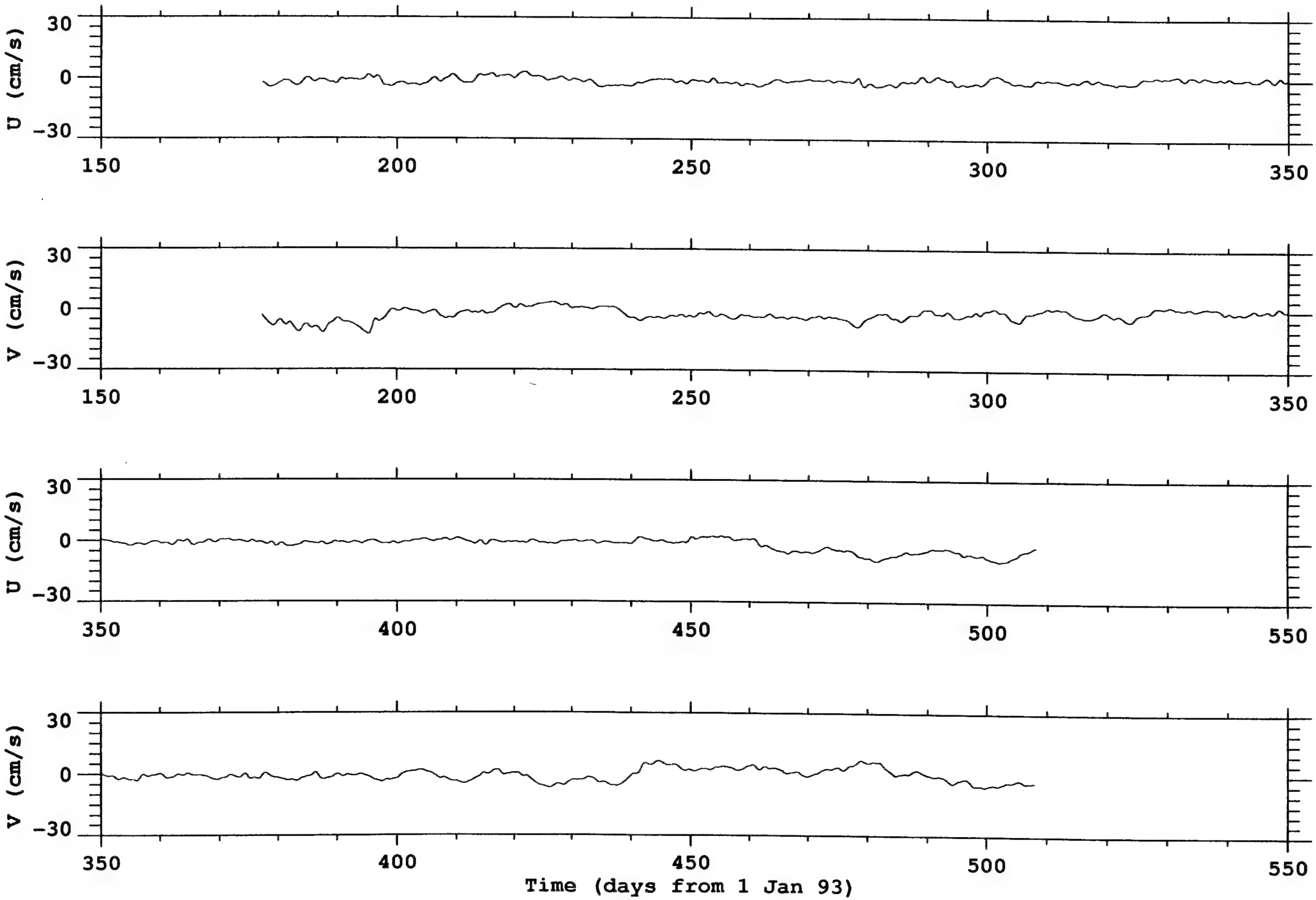
cm93b1-offset-1p

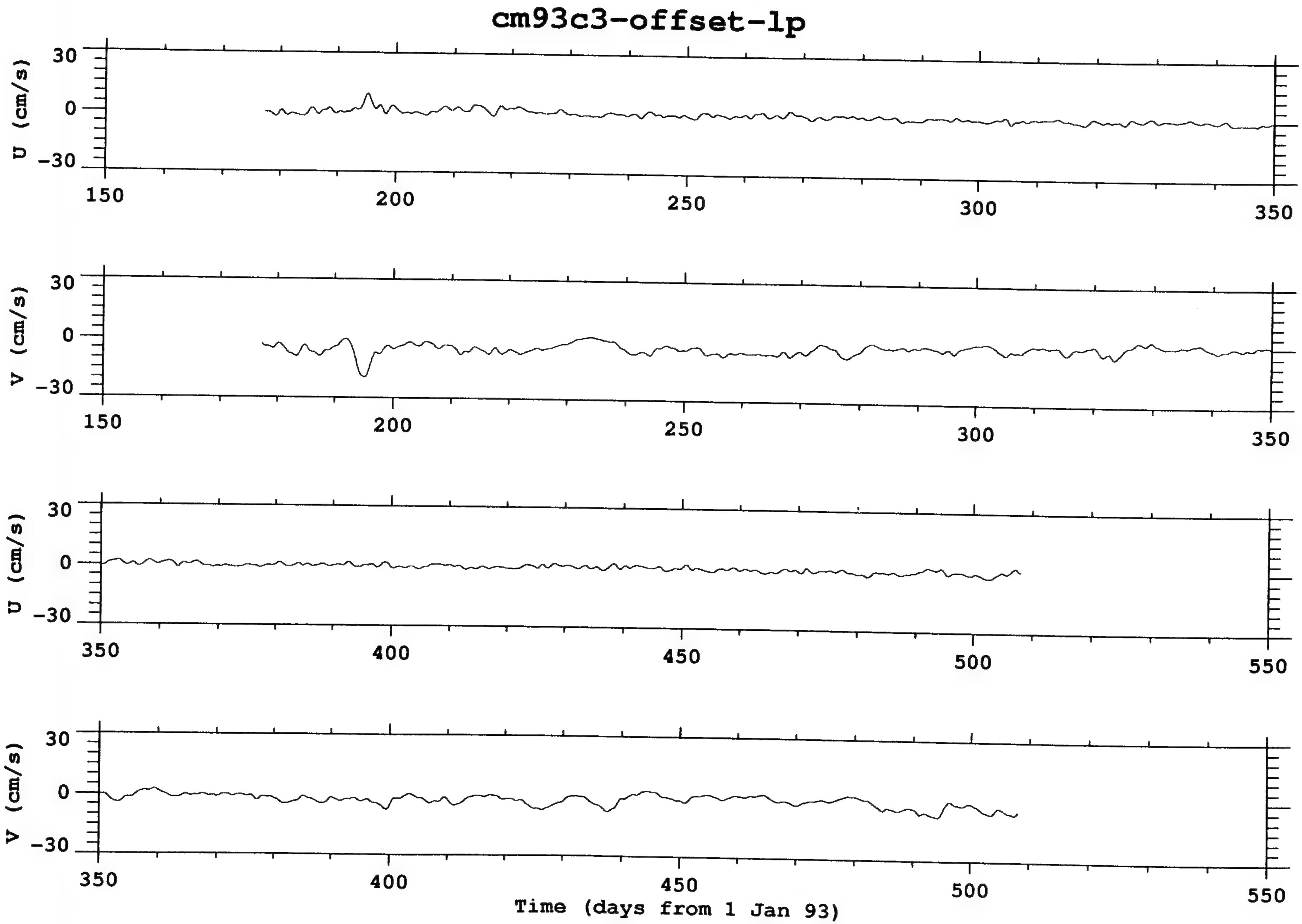


cm93c1-offset-1p

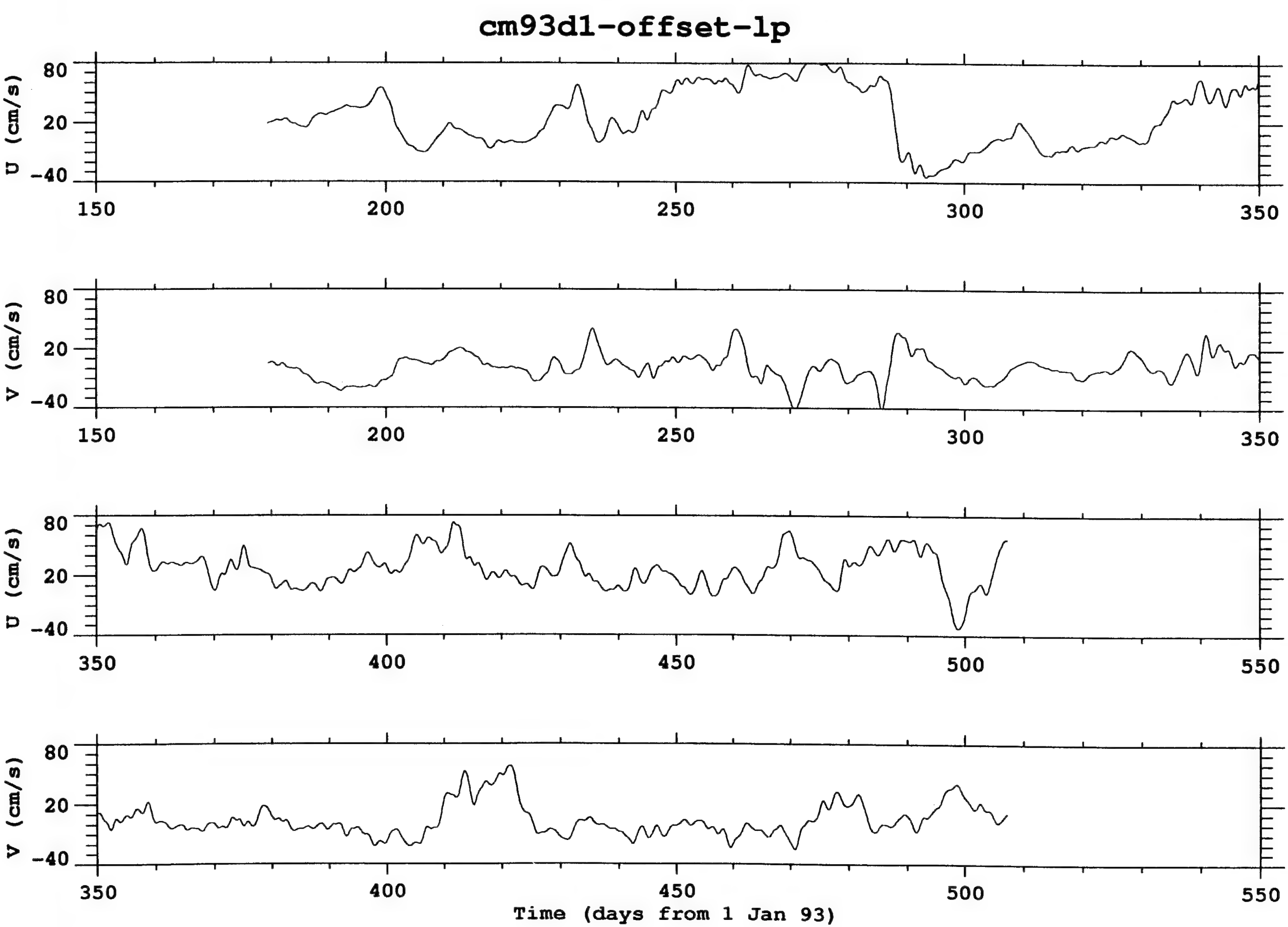


cm93c2-offset-lp



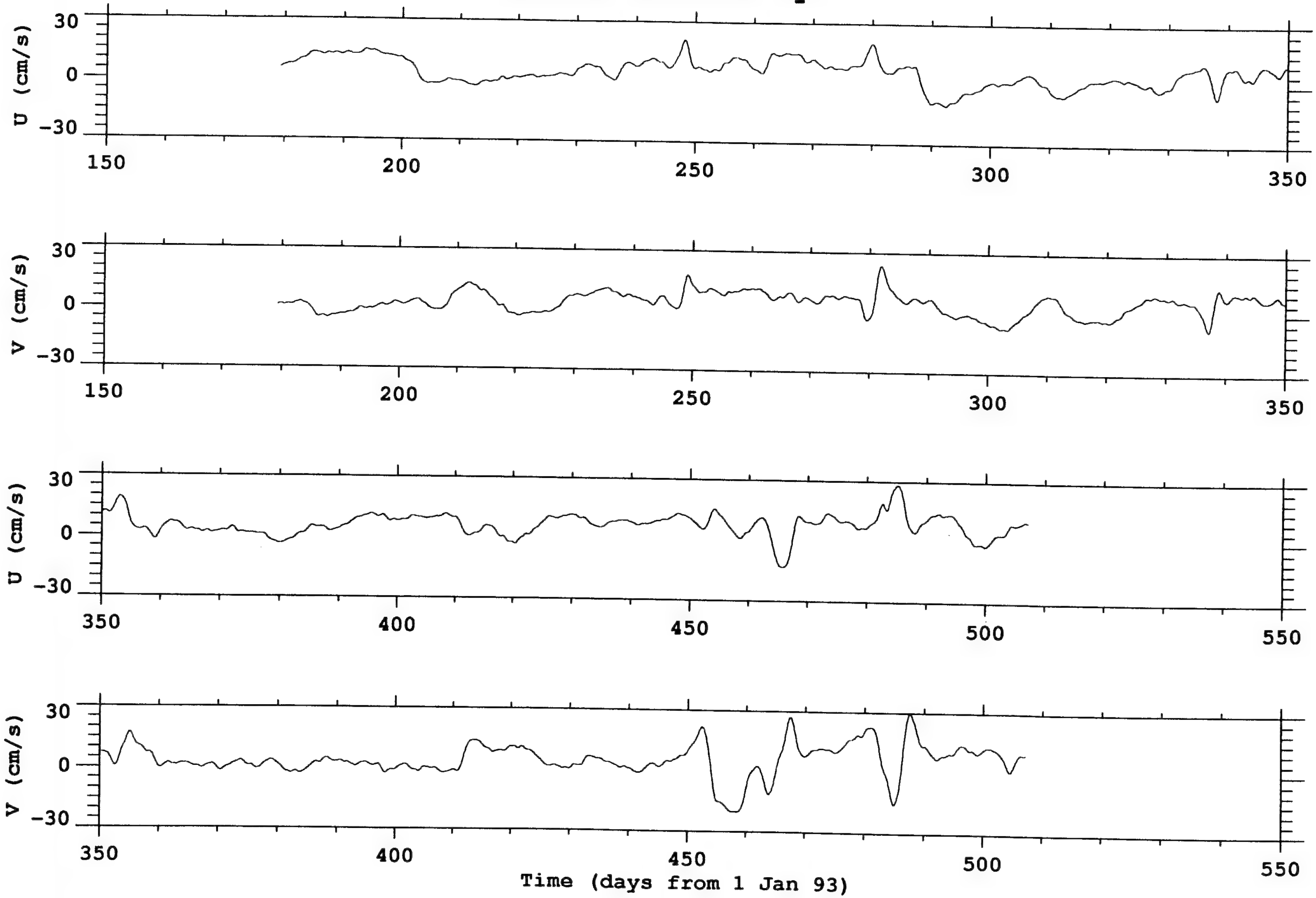


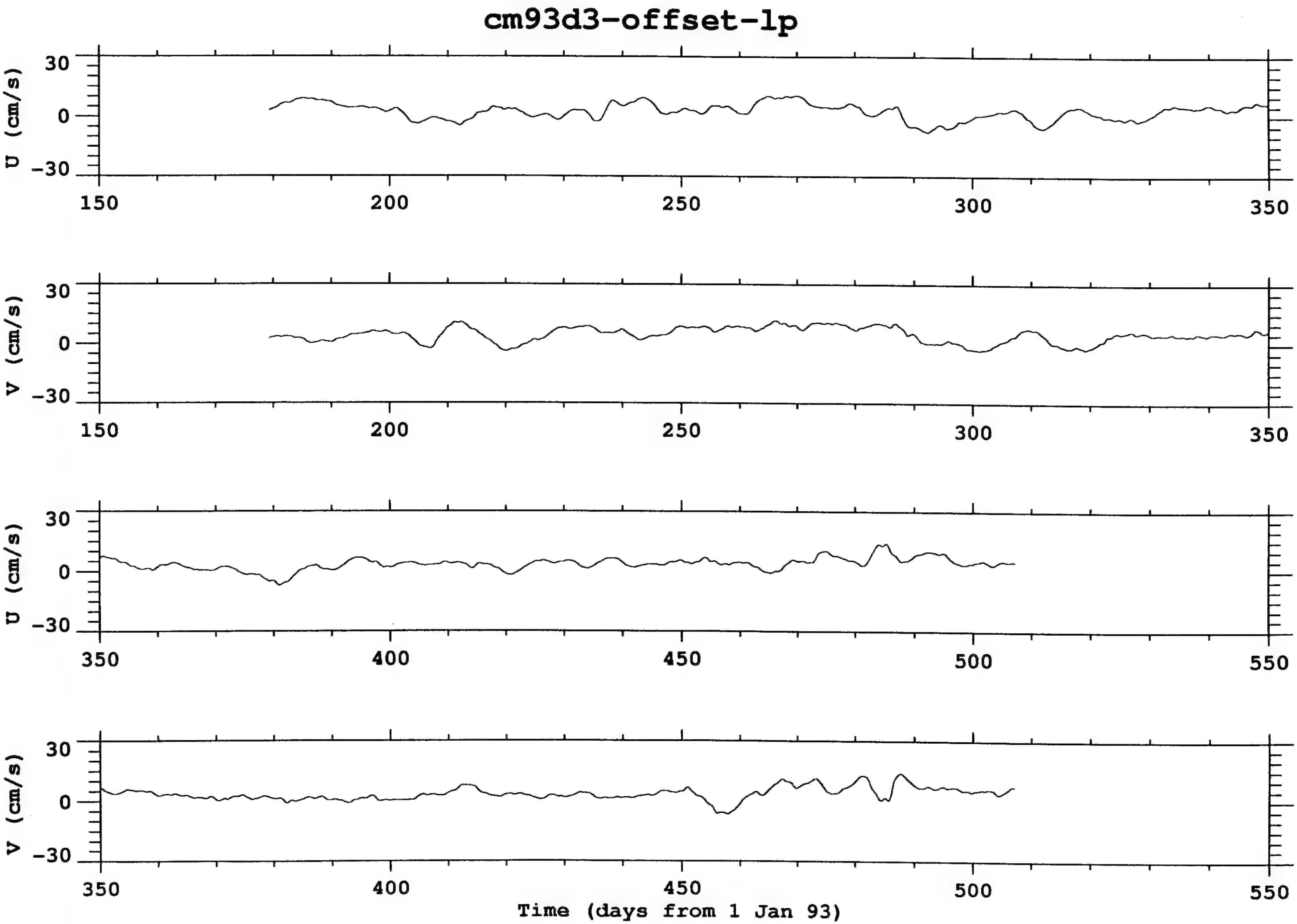
cm93c3-offset-1p
U (cm/s)
30
0
-30
150
200
250
300
350
V (cm/s)
30
0
-30
150
200
250
300
350
U (cm/s)
30
0
-30
350
400
450
500
550
V (cm/s)
30
0
-30
350
400
450
500
550
Time (days from 1 Jan 93)

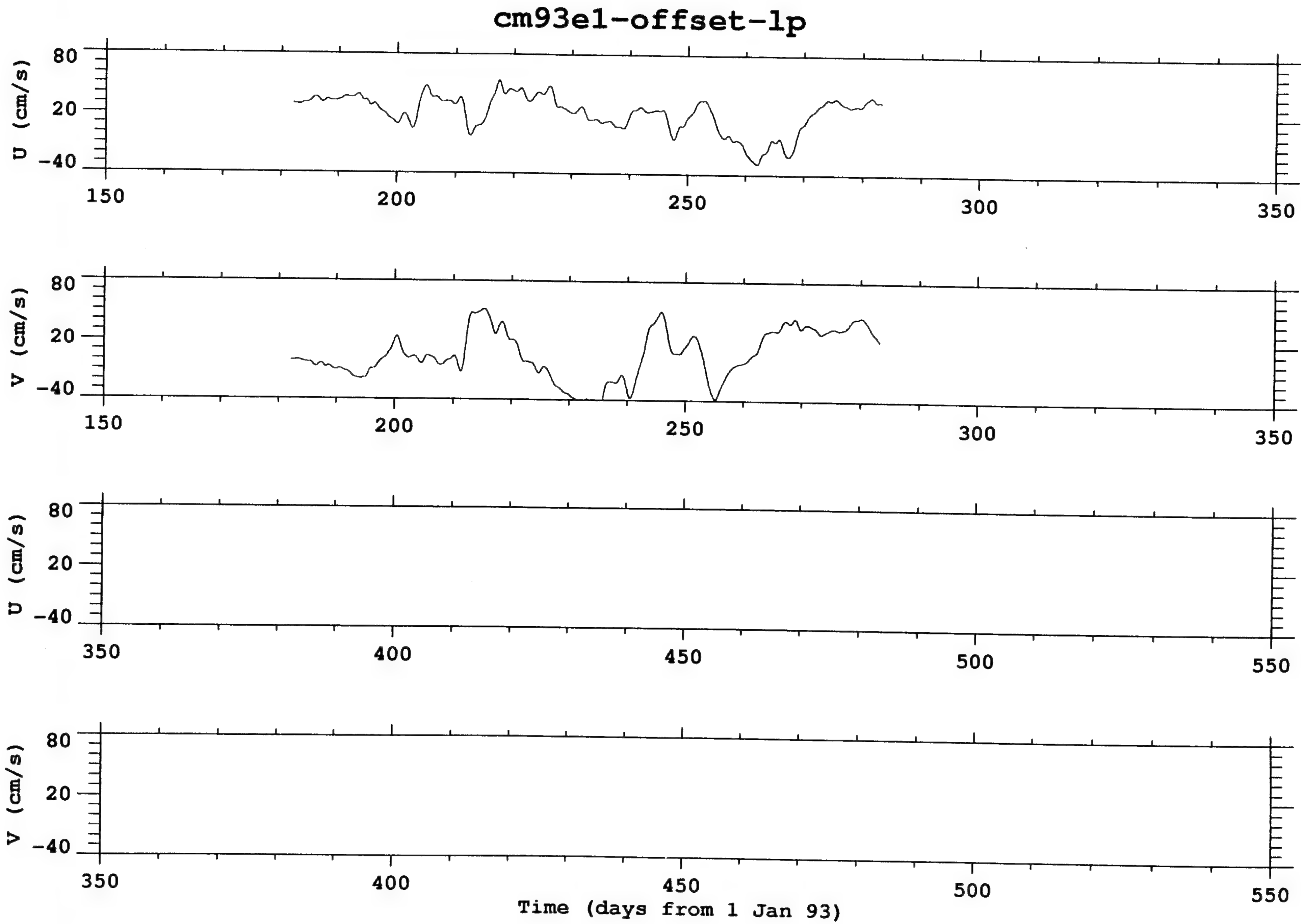


cm93d1-offset-lp
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
80
20
-40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

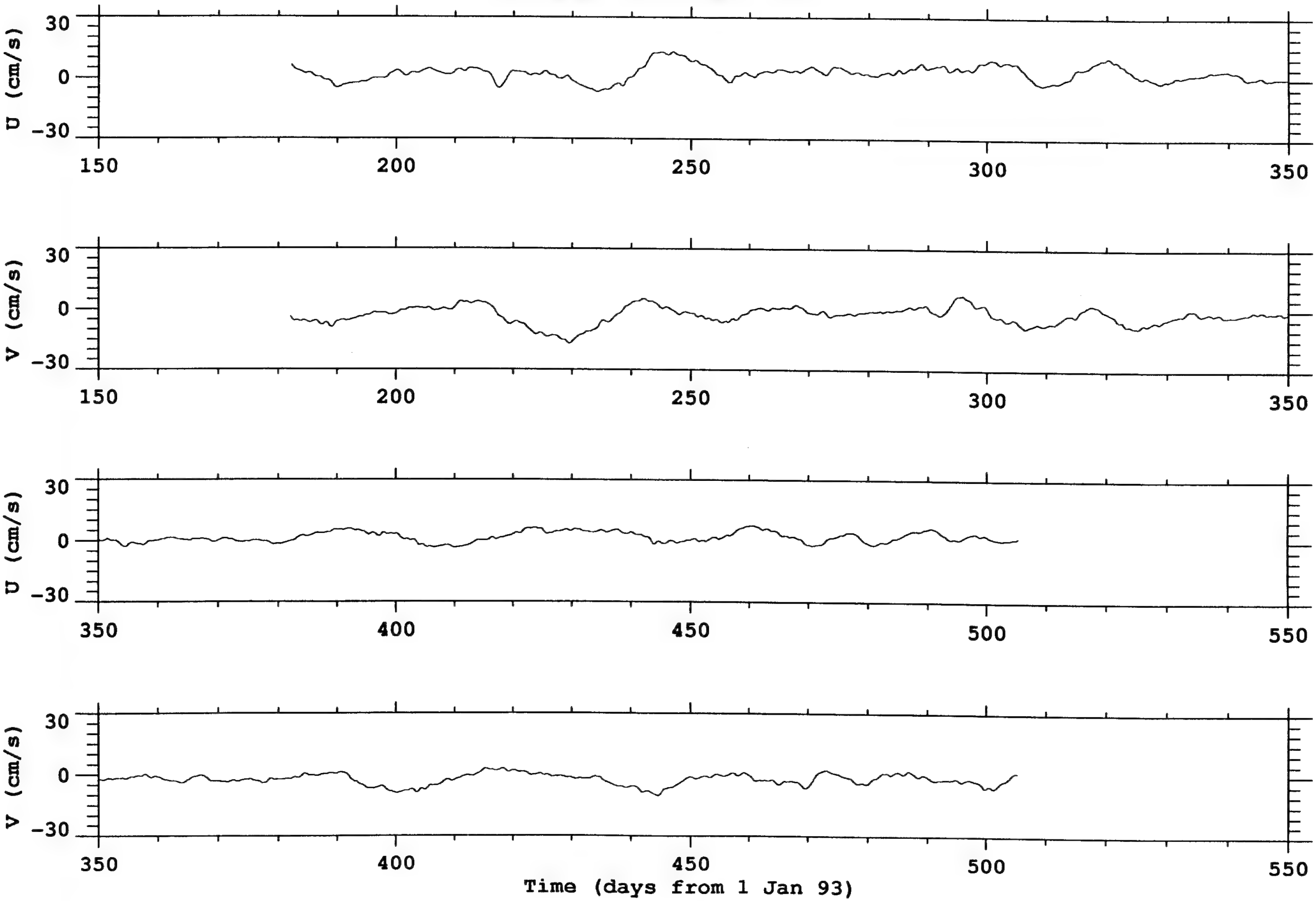
cm93d2-offset-1p



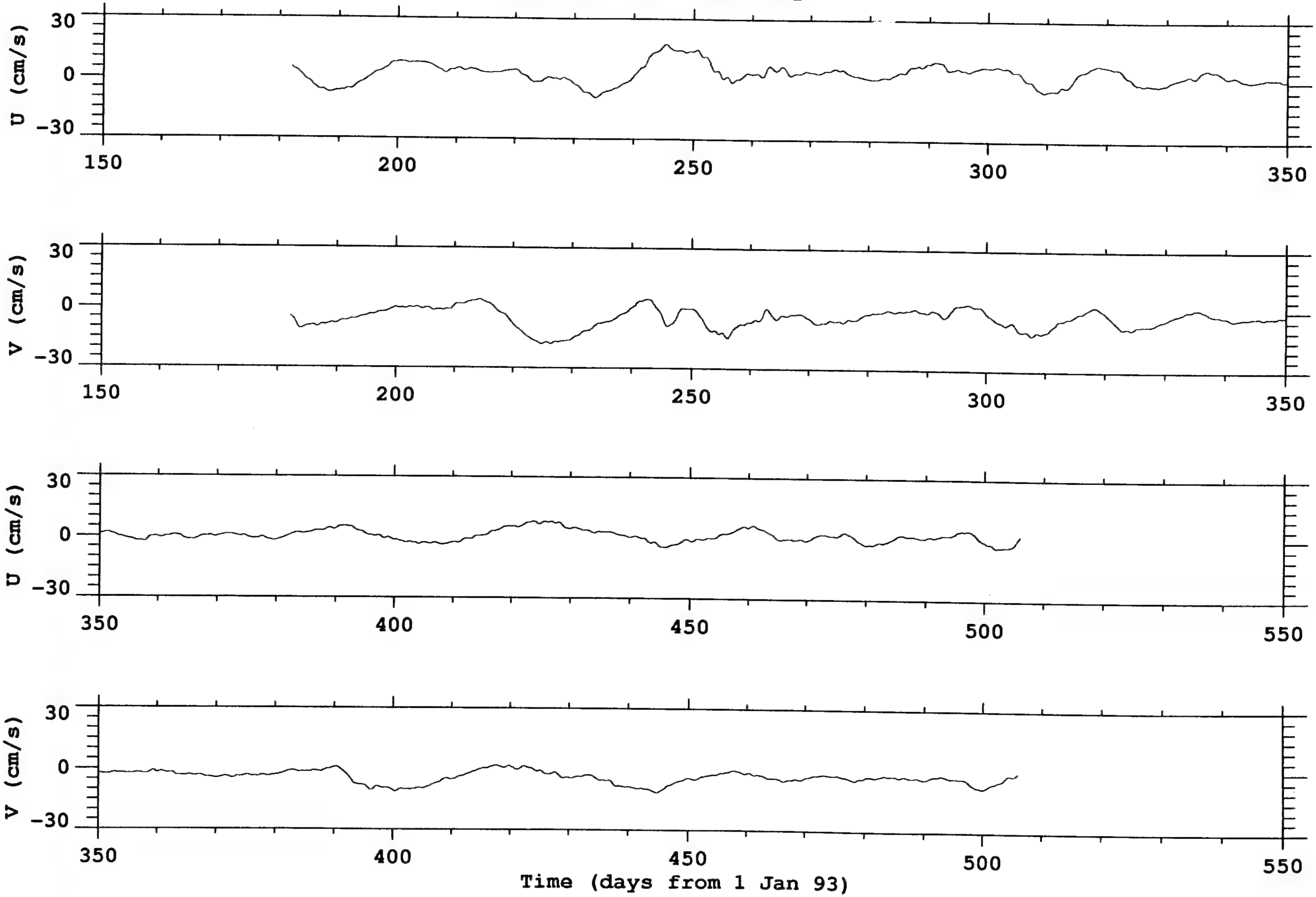

cm93d3-offset-lp
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
30
0
−30
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)


cm93e1-offset-lp
U (cm/s)
V (cm/s)
U (cm/s)
V (cm/s)
80
20
-40
150
200
250
300
350
400
450
500
550
Time (days from 1 Jan 93)

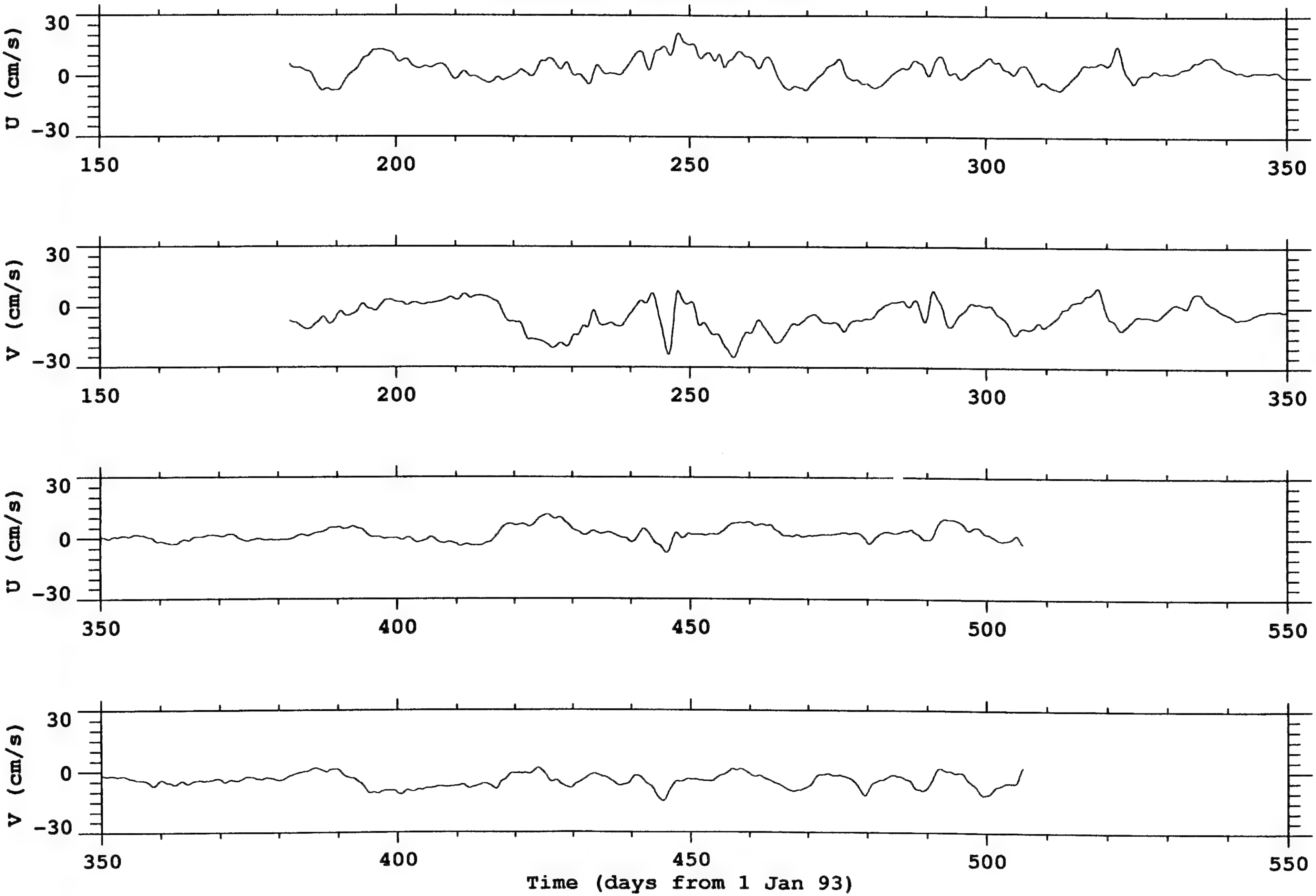
cm93e2-offset-1p



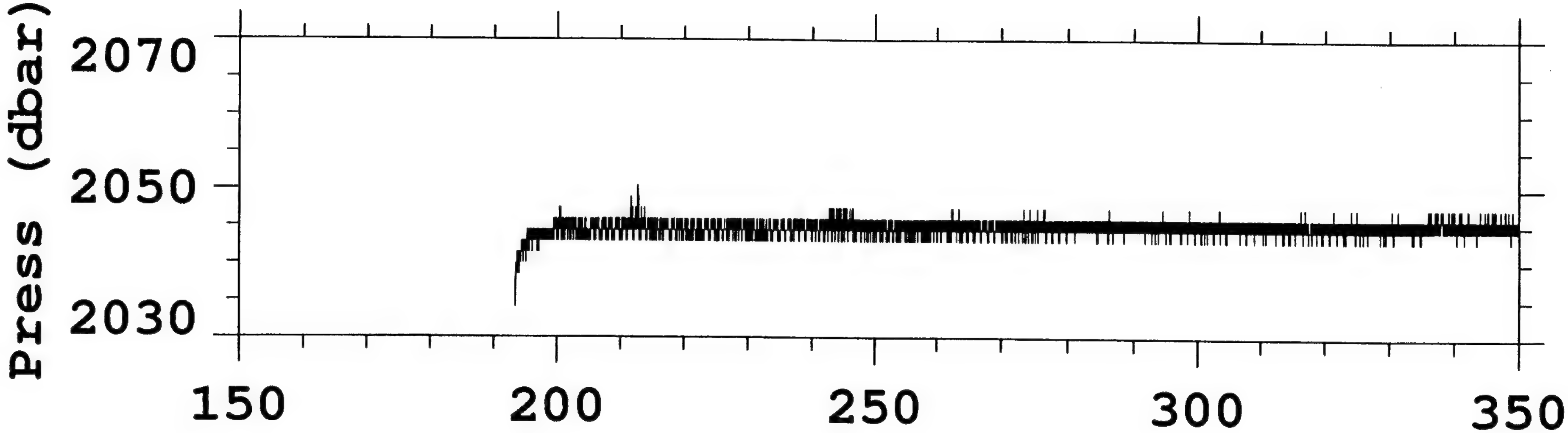
cm93e3-offset-1p



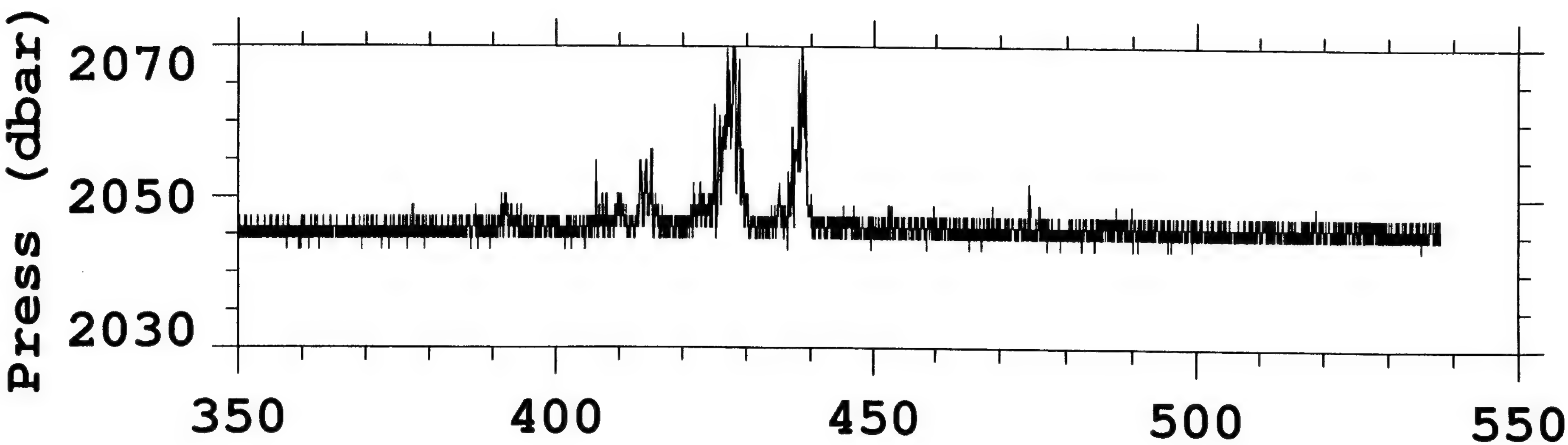
cm93e4-offset-1p



cm92b1

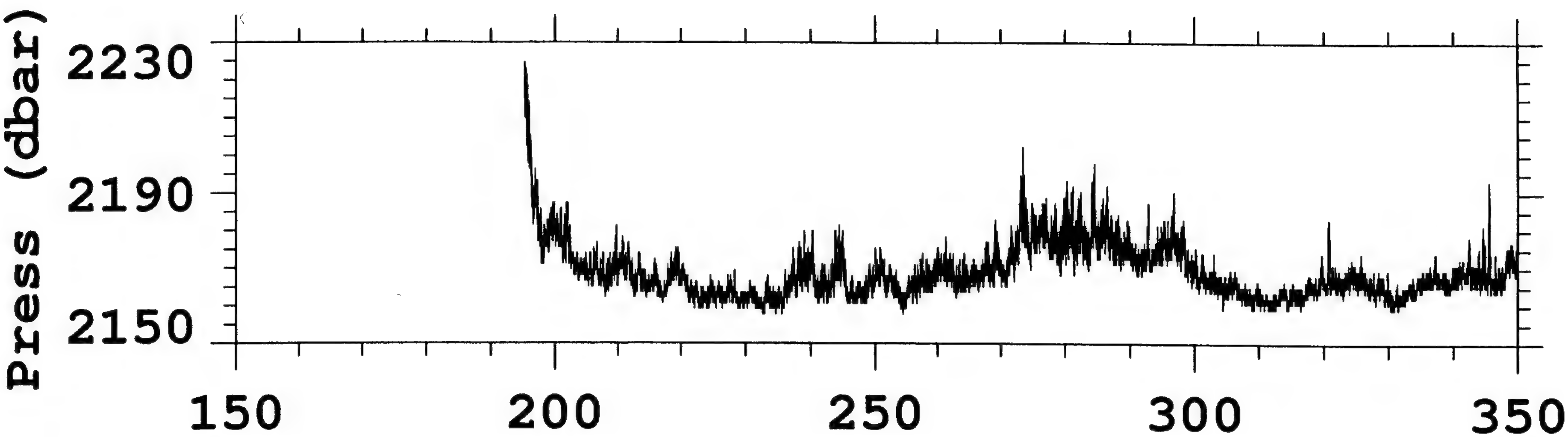


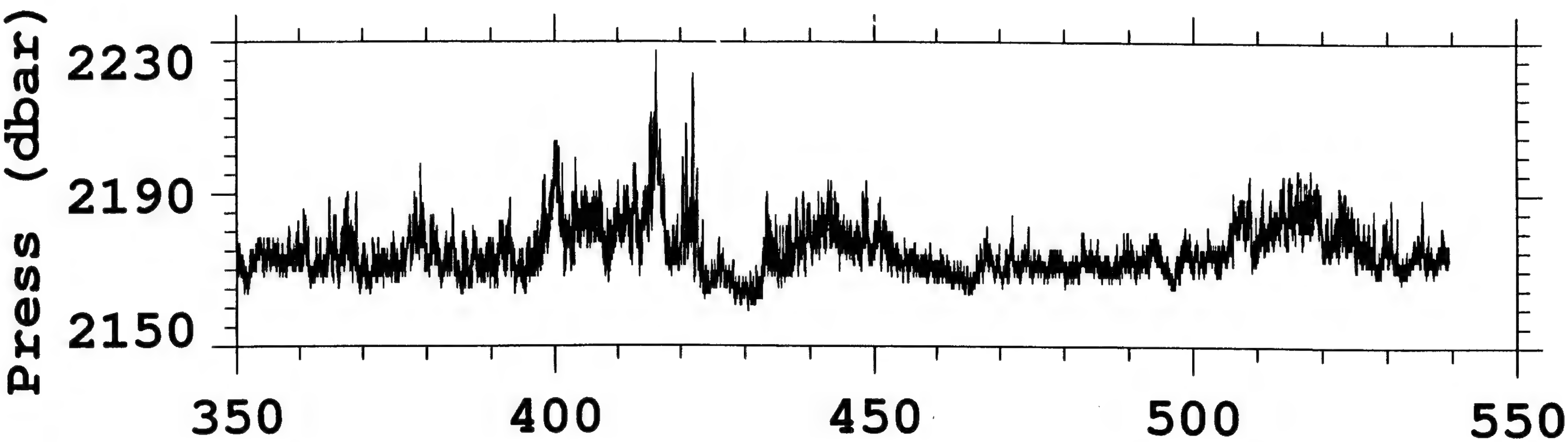
Press (dbar)
2070
2050
2030
150
200
250
300
350



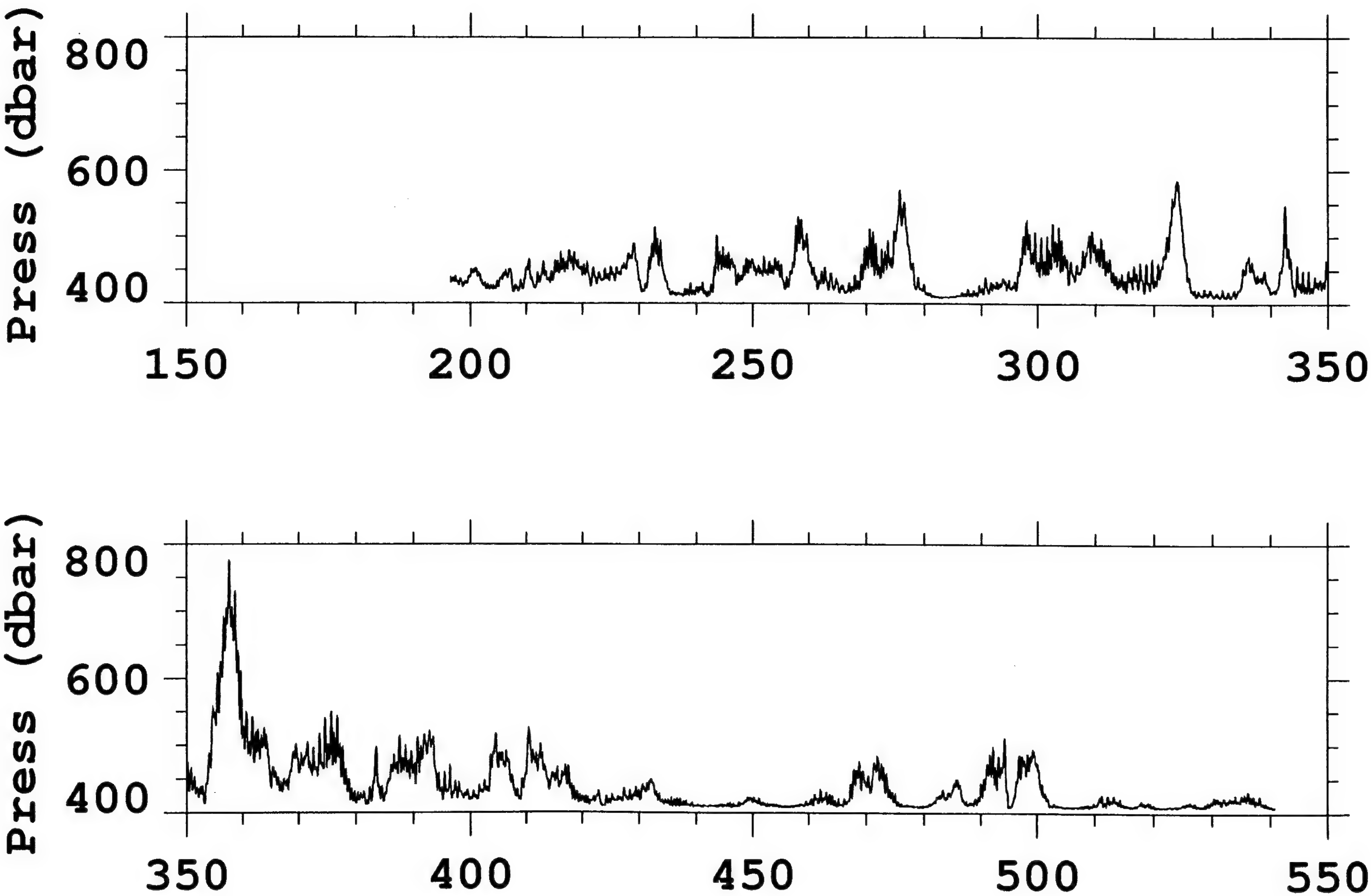
Press (dbar)
2070
2050
2030
350
400
450
500
550

cm92c1


Press (dbar)
2230
2190
2150
150
200
250
300
350

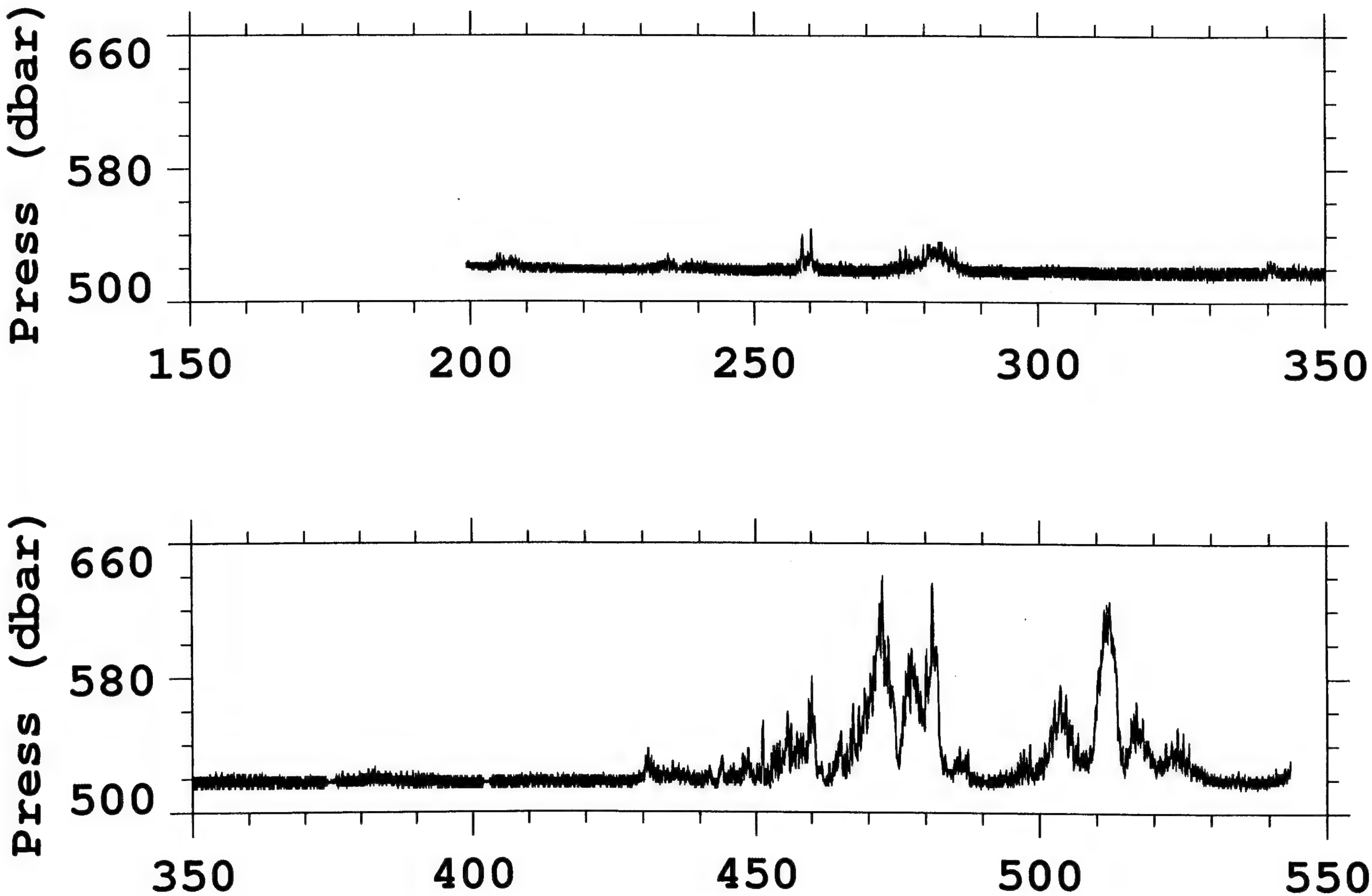

Press (dbar)
2230
2190
2150
350
400
450
500
550

cm92d1



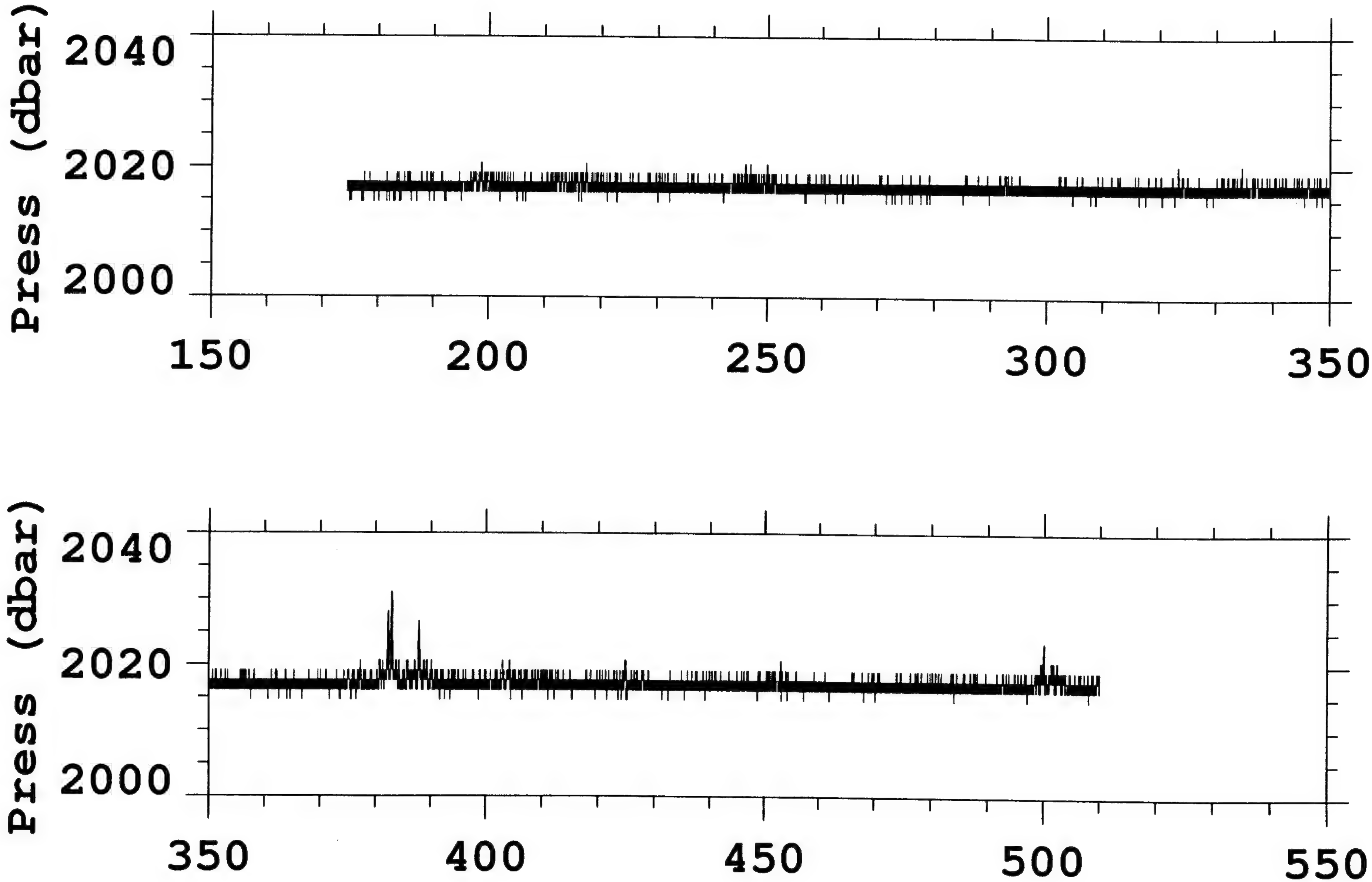
Press (dbar)
800
600
400
150
200
250
300
350
Press (dbar)
800
600
400
350
400
450
500
550

cm92e1



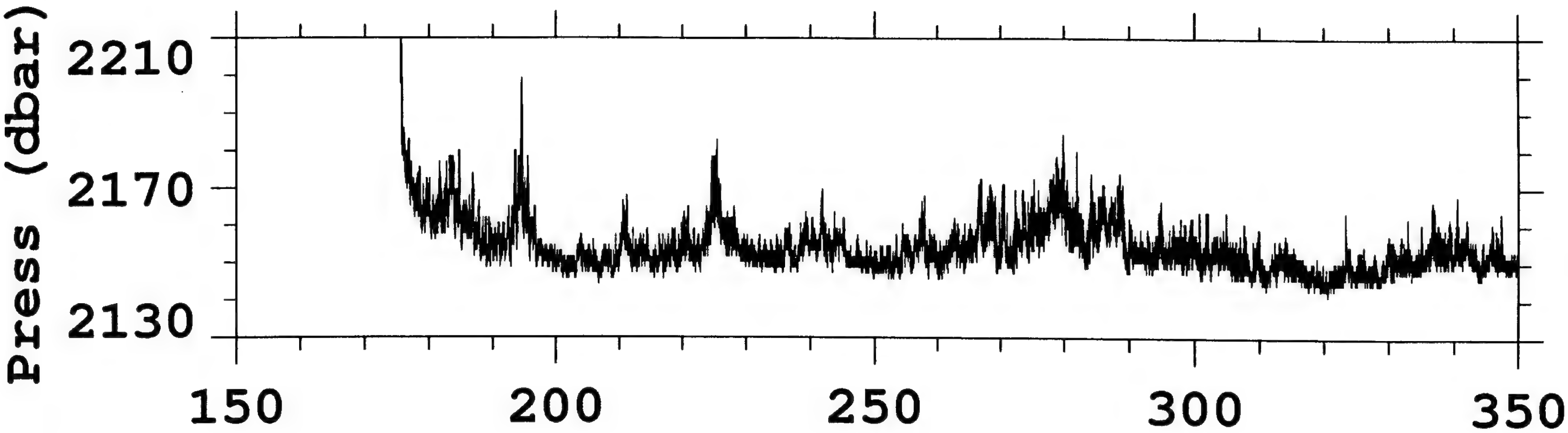
Press (dbar)
660
580
500
150
200
250
300
350
Press (dbar)
660
580
500
350
400
450
500
550

cm93b1

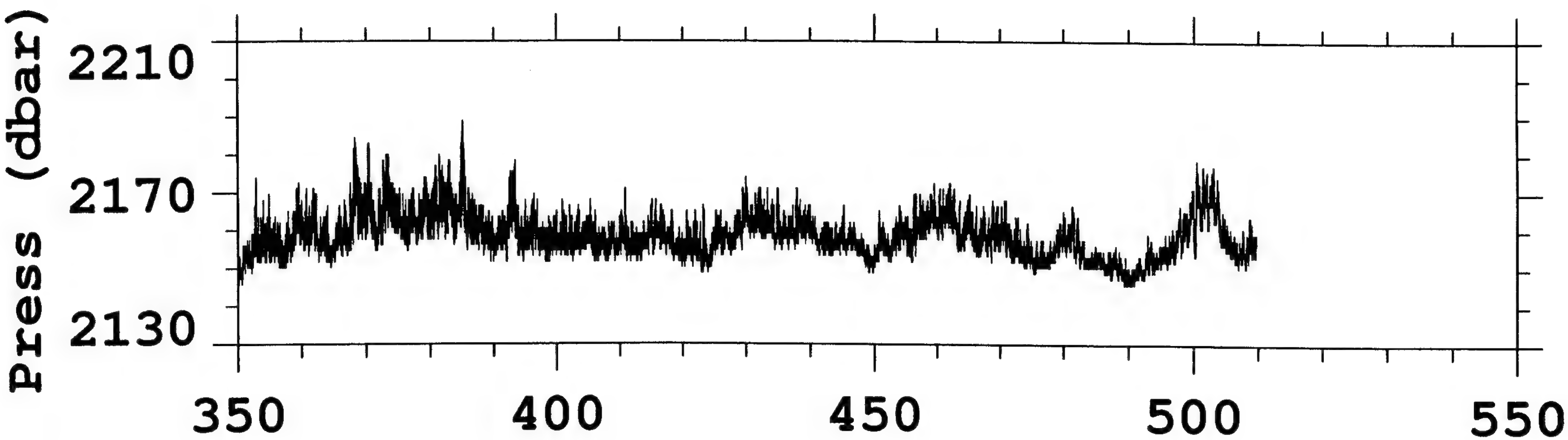


Press (dbar)
2040
2020
2000
150
200
250
300
350
Press (dbar)
2040
2020
2000
350
400
450
500
550

cm93c1

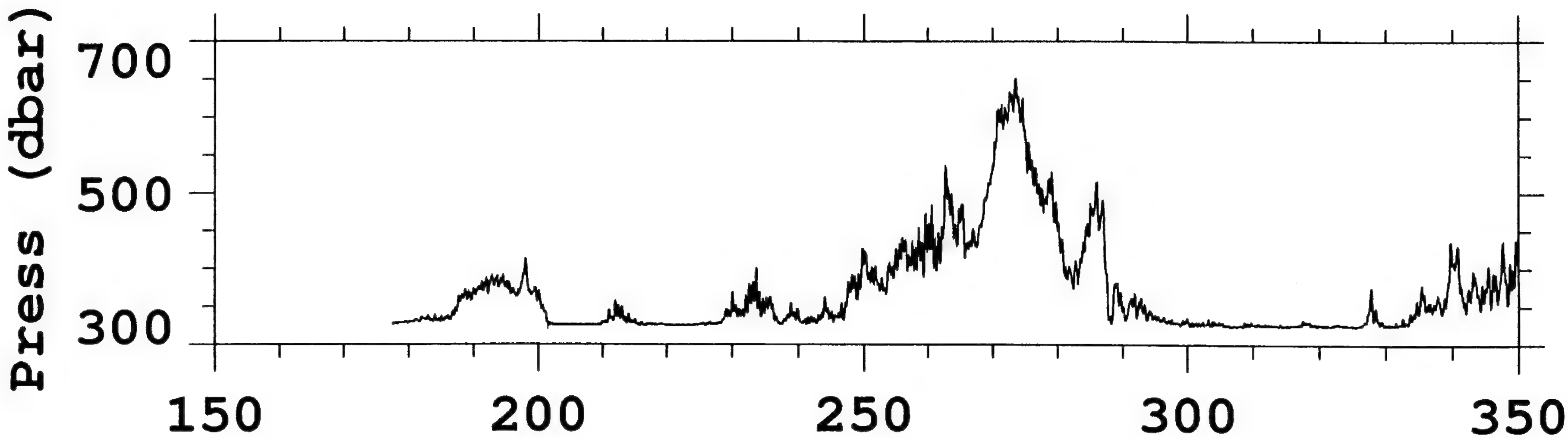


Press (dbar)
2210
2170
2130
150
200
250
300
350

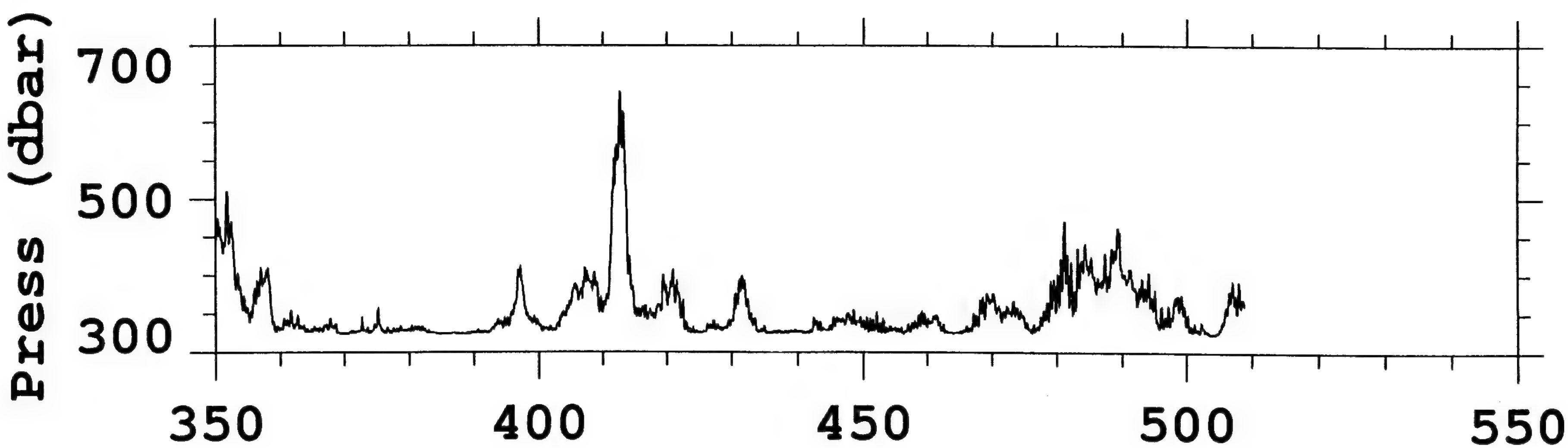


Press (dbar)
2210
2170
2130
350
400
450
500
550

cm93d1

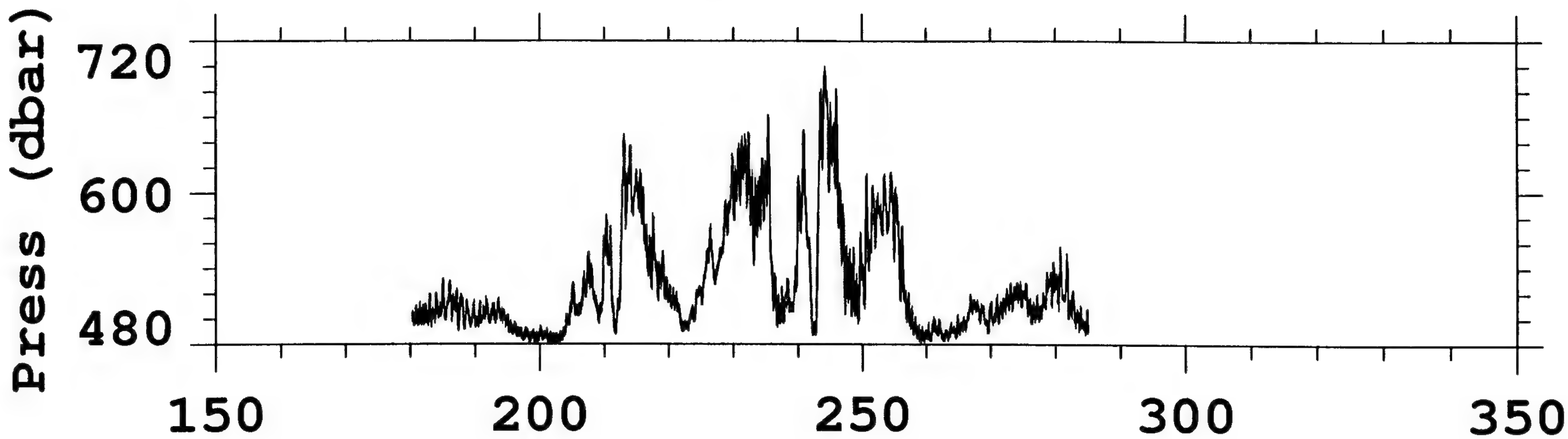


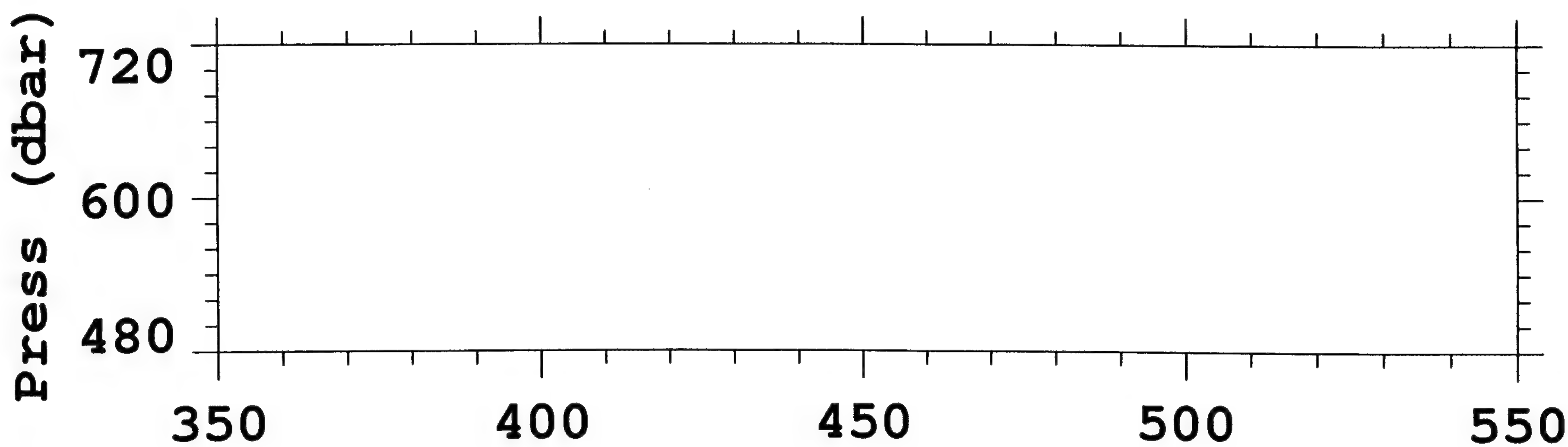
Press (dbar)
700
500
300
150
200
250
300
350



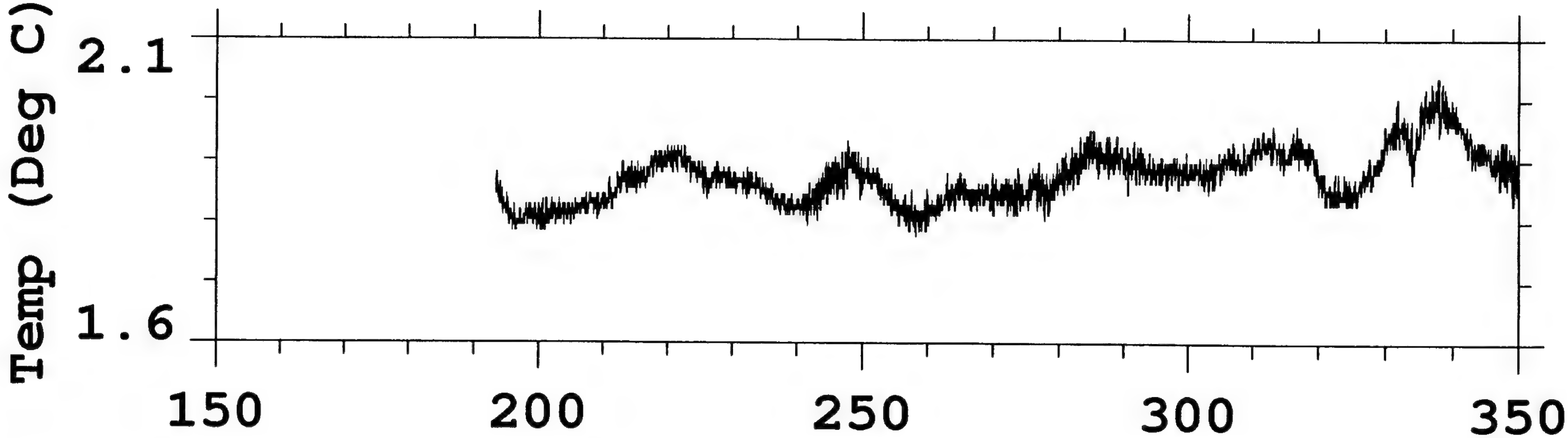
Press (dbar)
700
500
300
350
400
450
500
550

cm93e1

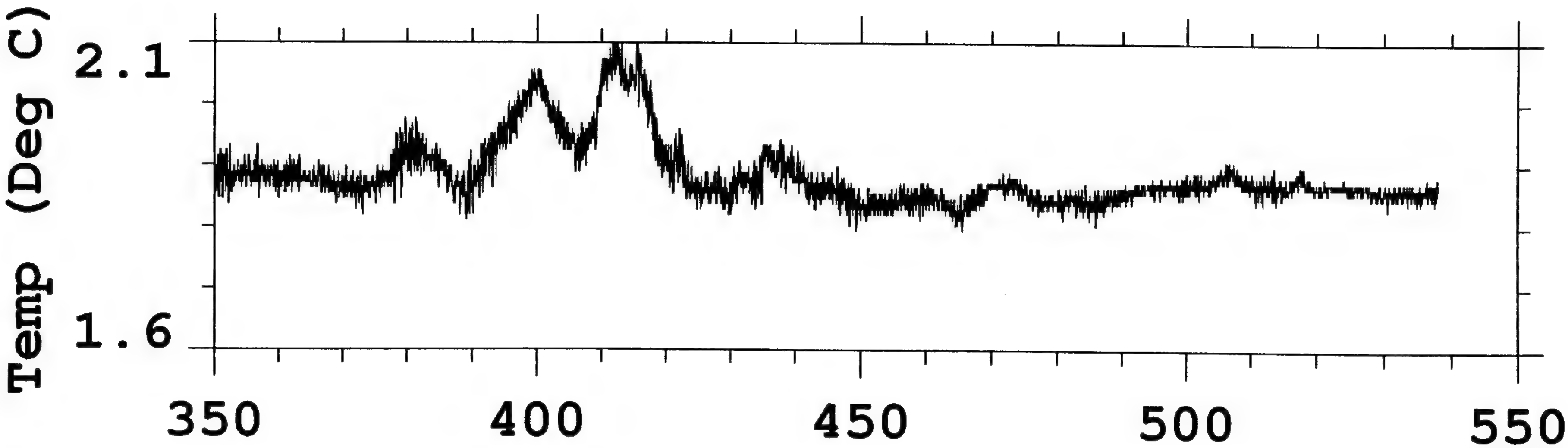

Press (dbar)
720
600
480
150
200
250
300
350


Press (dbar)
720
600
480
350
400
450
500
550

cm92b1

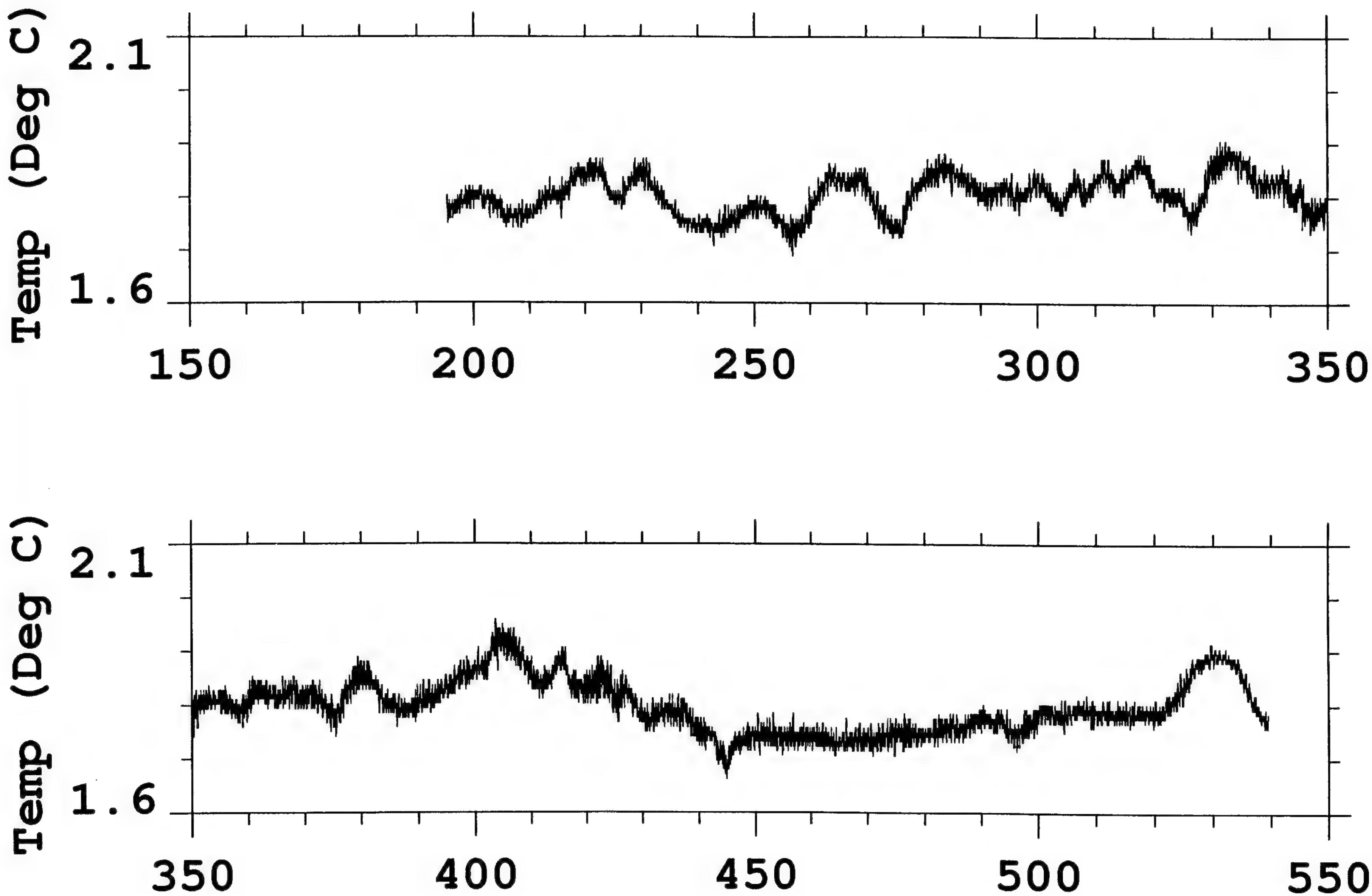


Temp (Deg C)
2.1
1.6
150
200
250
300
350

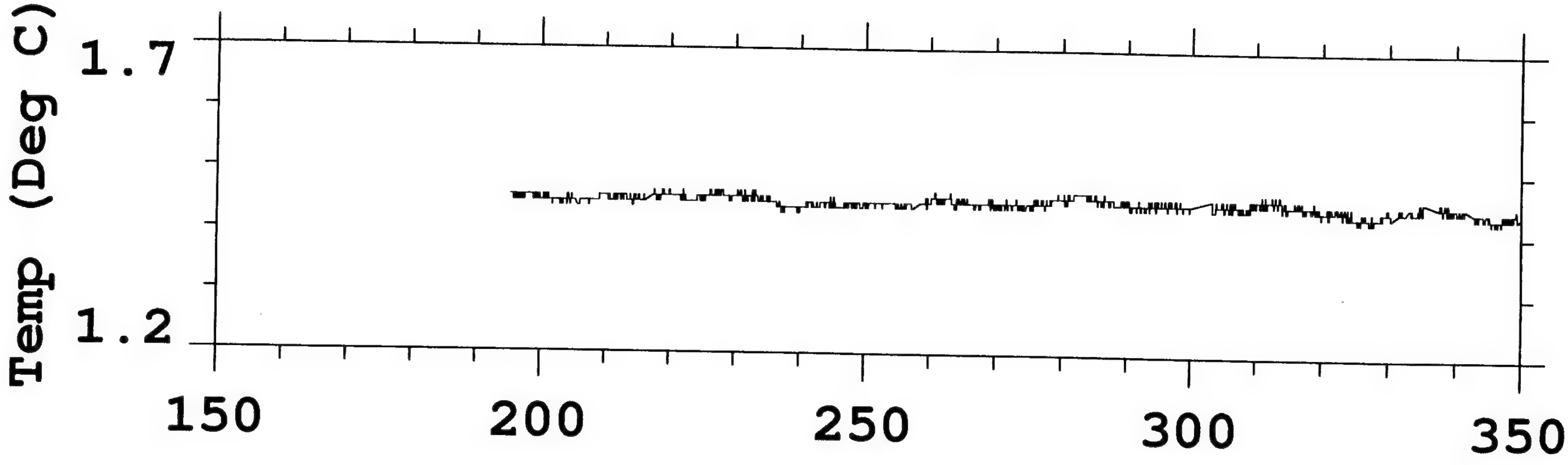


Temp (Deg C)
2.1
1.6
350
400
450
500
550

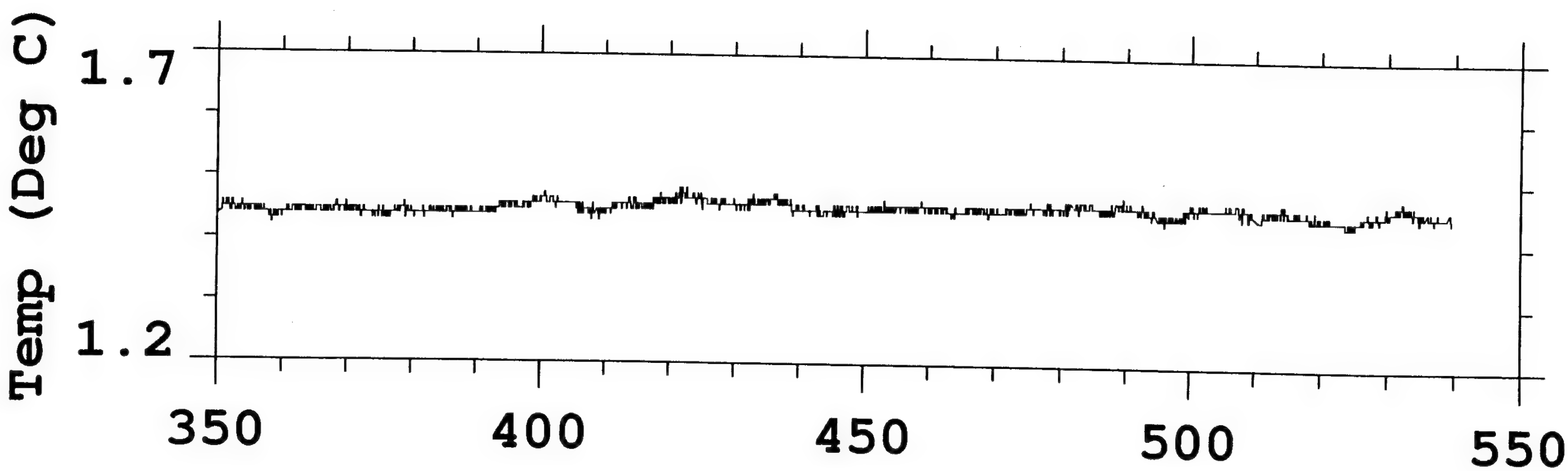
cm92c1


Temp (Deg C)
2.1
1.6
150
200
250
300
350
Temp (Deg C)
2.1
1.6
350
400
450
500
550

cm92c3

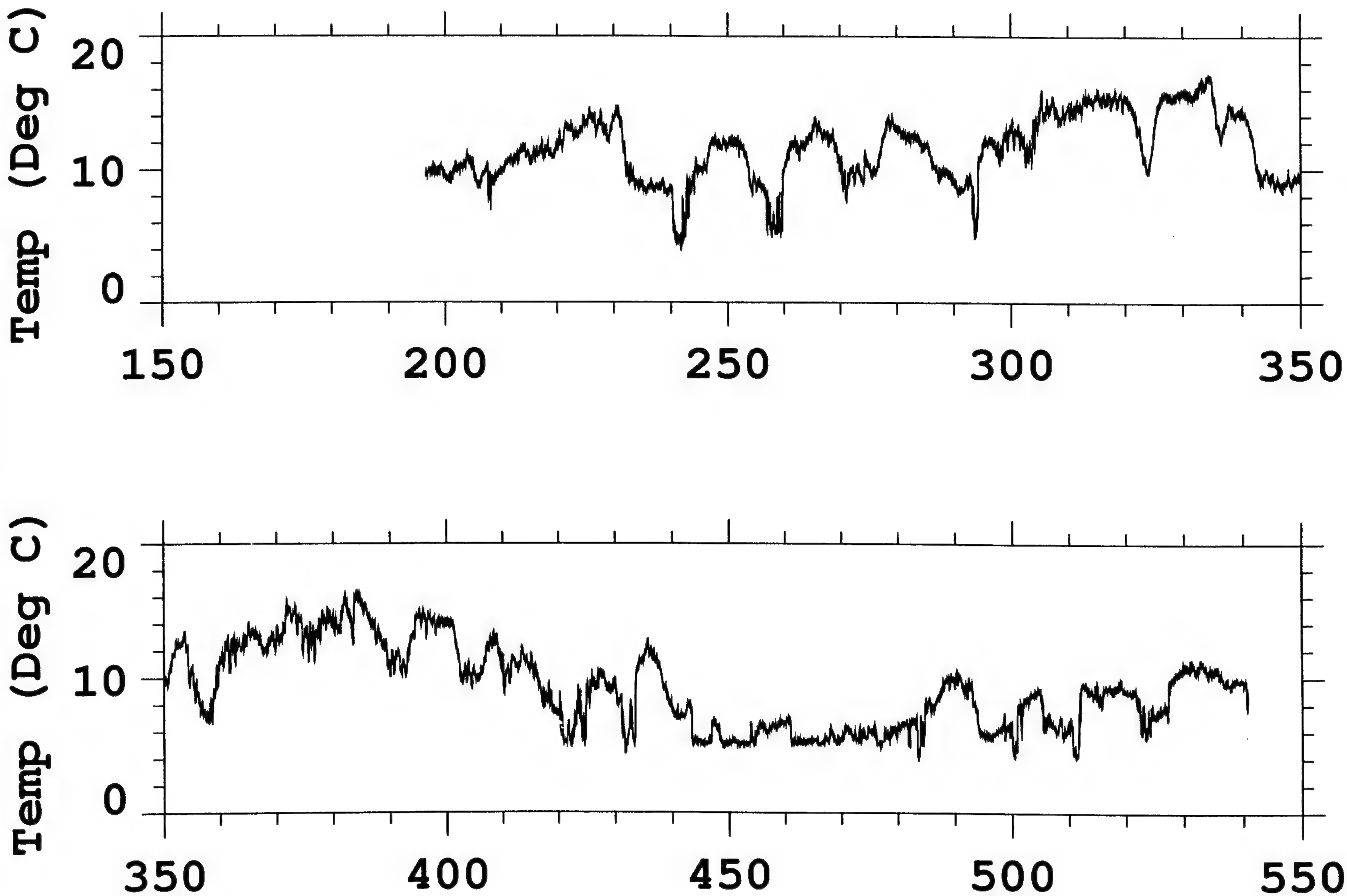


Temp (Deg C)
1.7
1.2
150
200
250
300
350



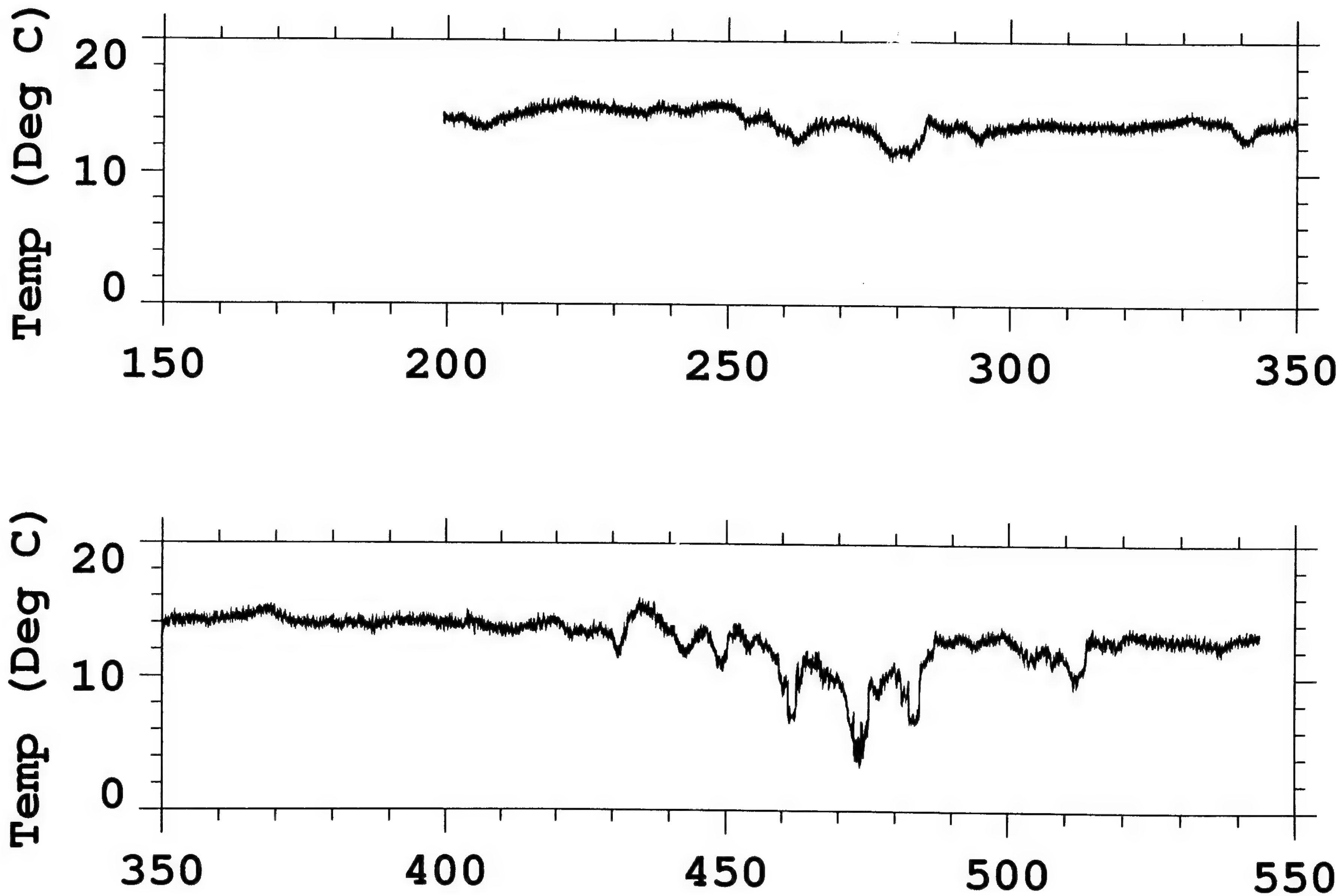
Temp (Deg C)
1.7
1.2
350
400
450
500
550

cm92d1

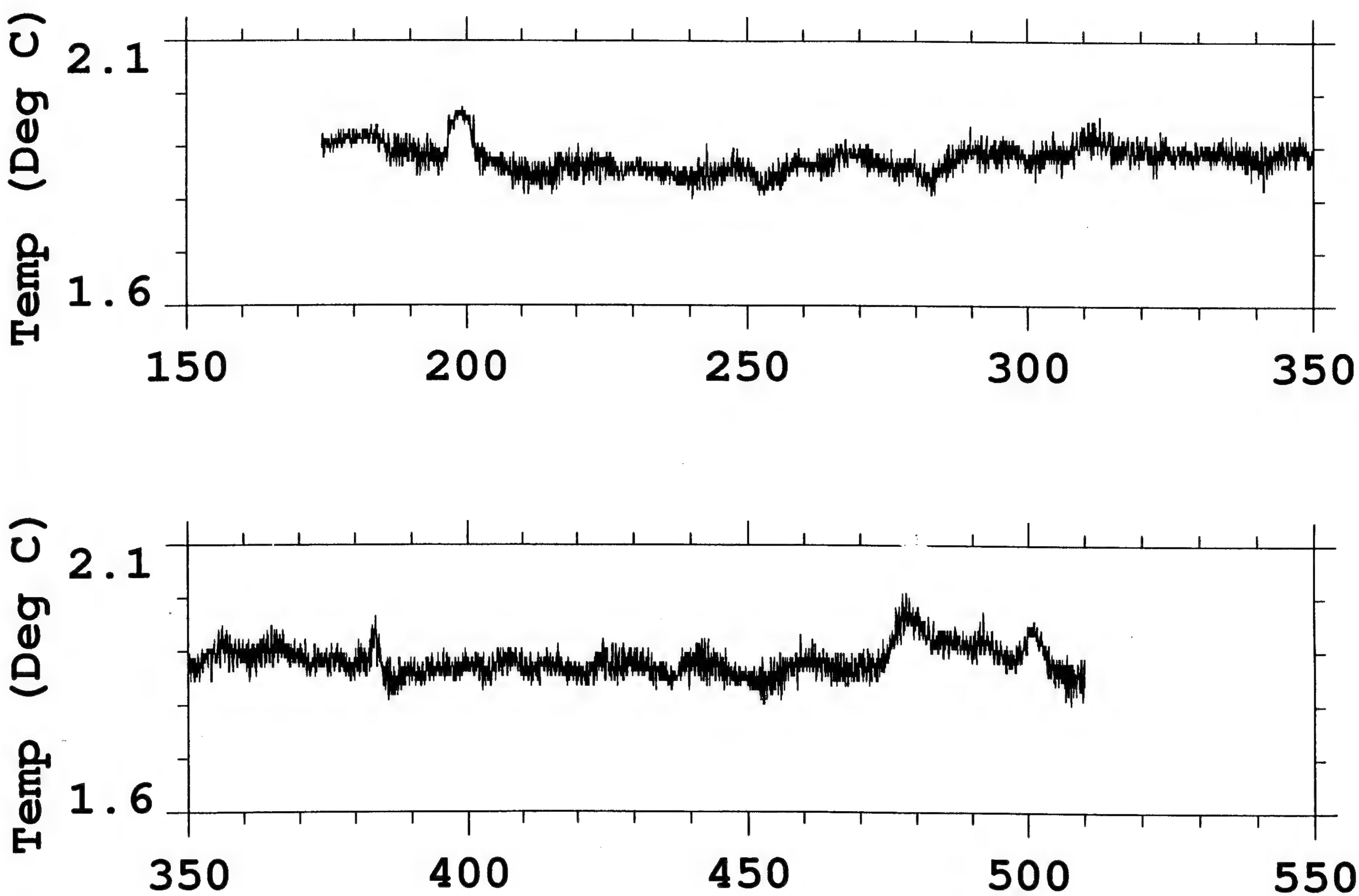


Temp (Deg C)
20
10
0
150
200
250
300
350
Temp (Deg C)
20
10
0
350
400
450
500
550

cm92e1

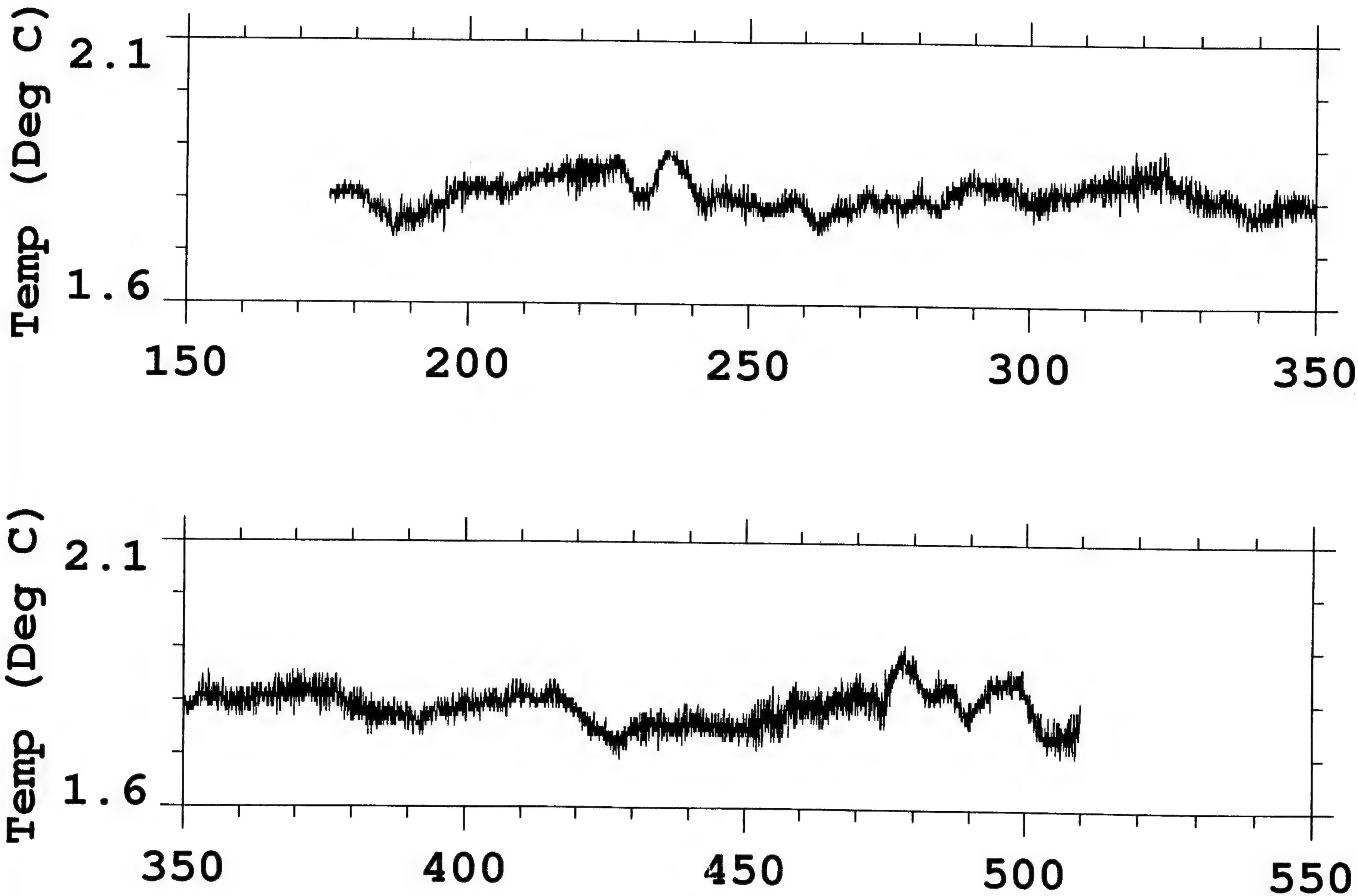

Temp (Deg C)
20
10
0
150
200
250
300
350
Temp (Deg C)
20
10
0
350
400
450
500
550

cm93b1



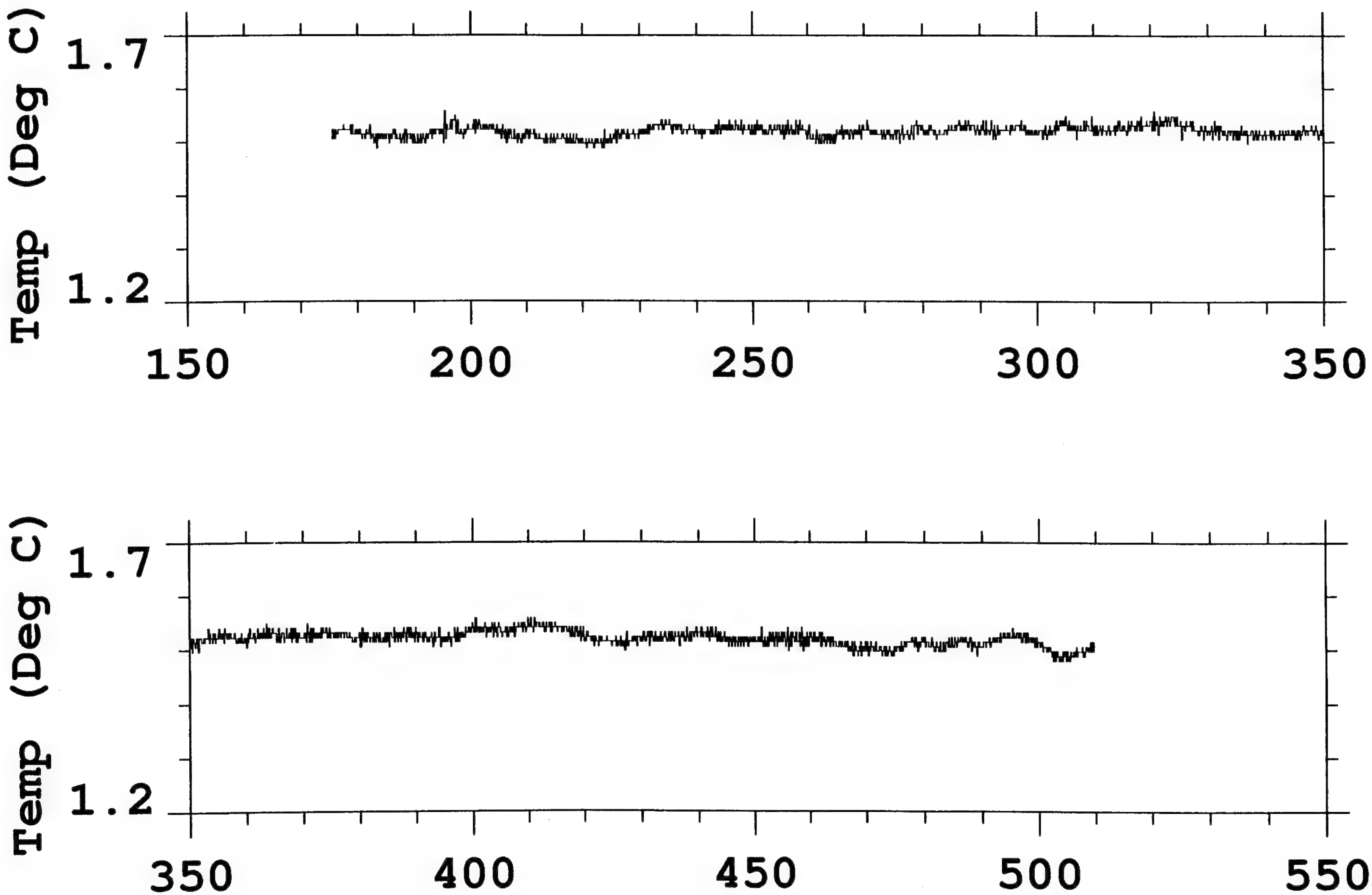
Temp (Deg C)
2.1
1.6
150
200
250
300
350
Temp (Deg C)
2.1
1.6
350
400
450
500
550

cm93c1



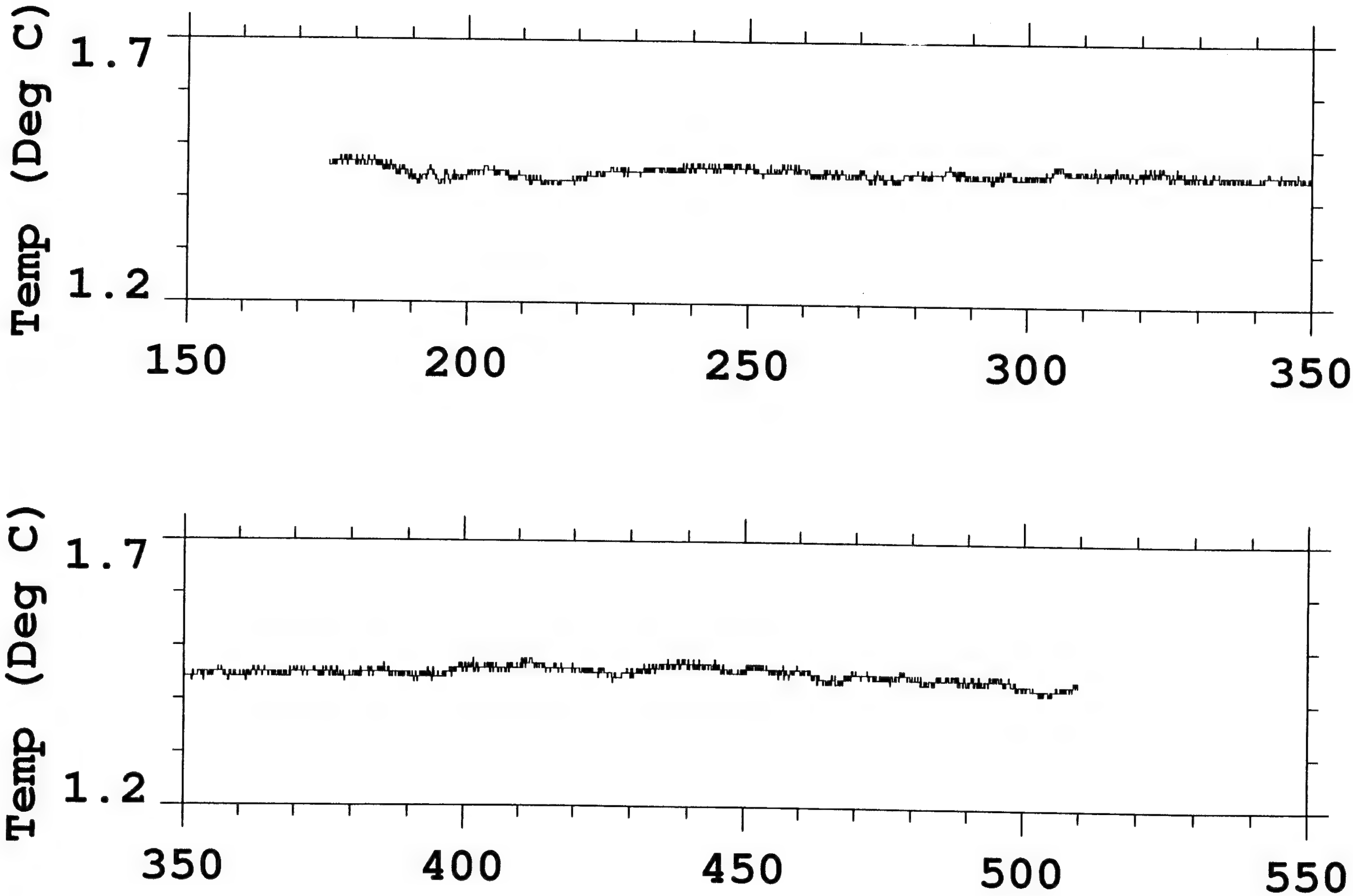
Temp (Deg C)
2.1
1.6
150
200
250
300
350
Temp (Deg C)
2.1
1.6
350
400
450
500
550

cm93c2



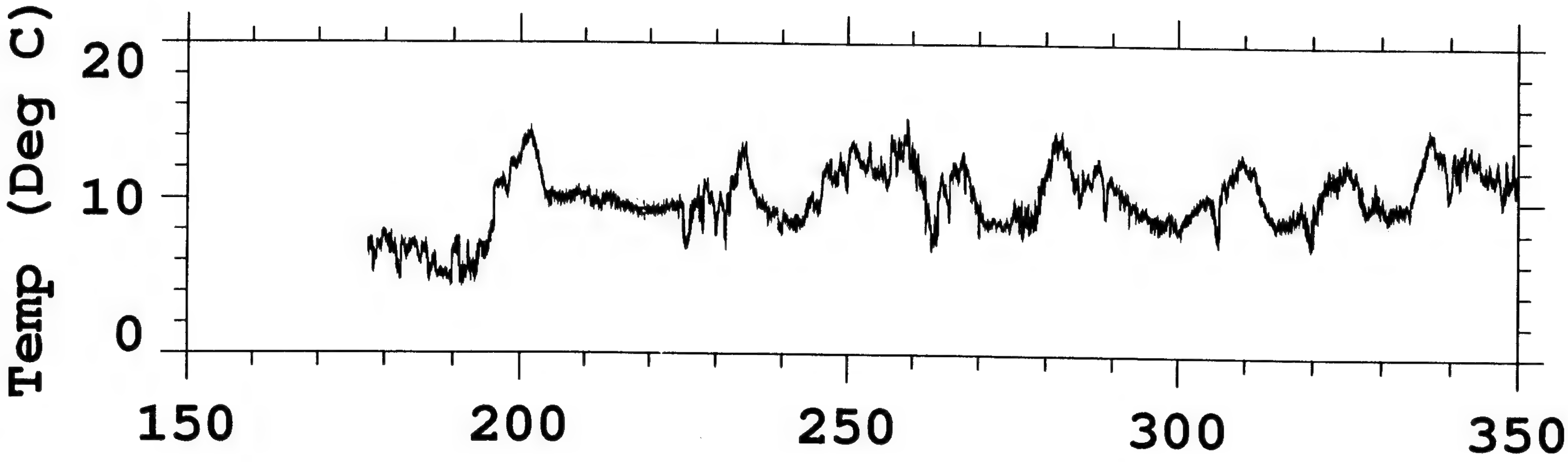
Temp (Deg C)
1.7
1.2
150
200
250
300
350
Temp (Deg C)
1.7
1.2
350
400
450
500
550

cm93c3

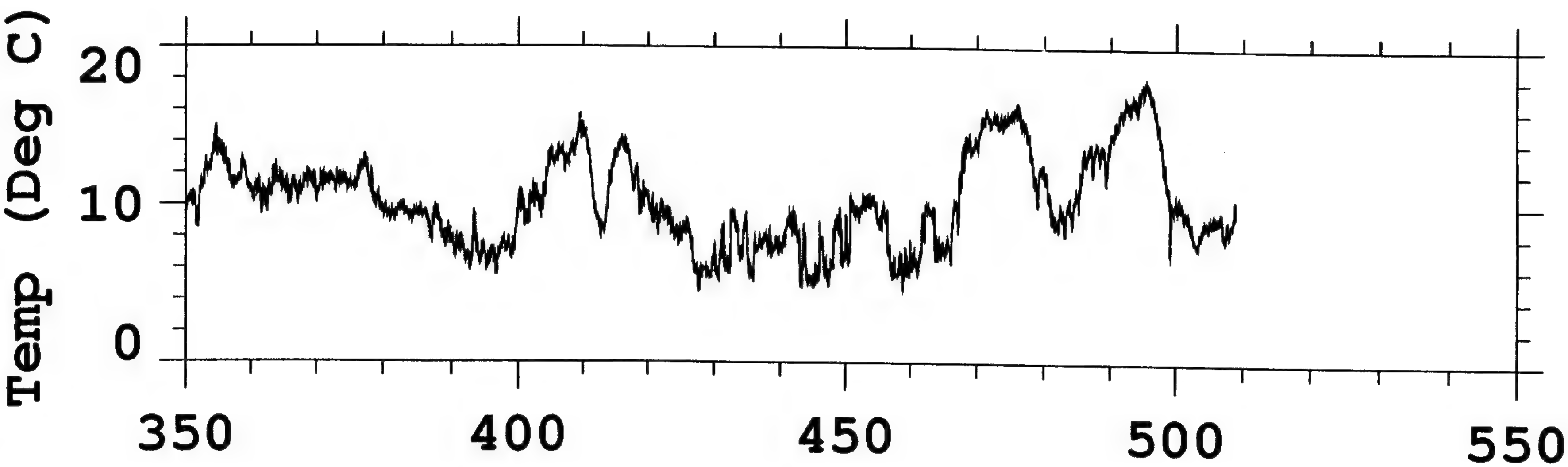


Temp (Deg C)
1.7
1.2
150
200
250
300
350
Temp (Deg C)
1.7
1.2
350
400
450
500
550

cm93d1

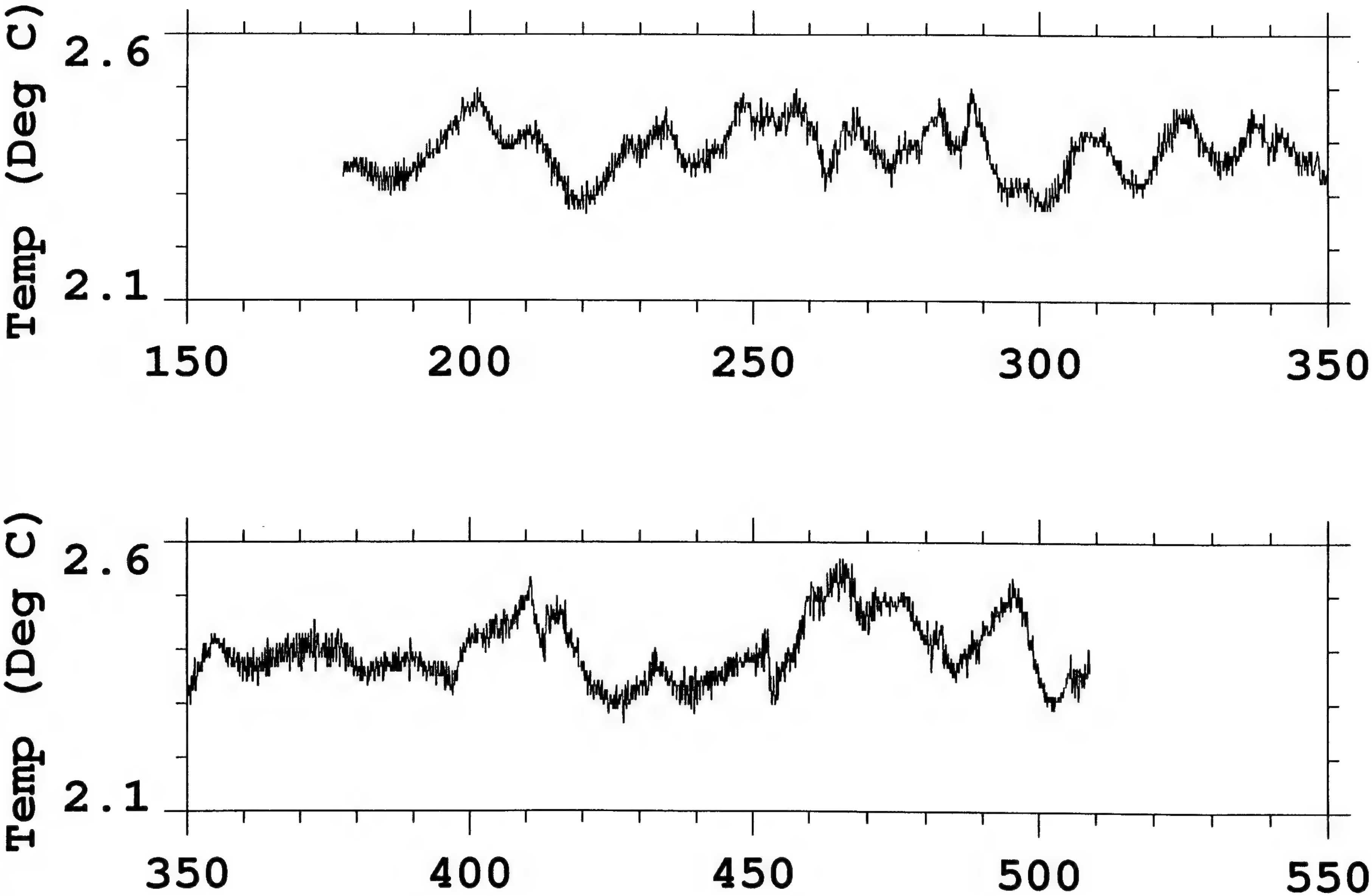


Temp (Deg C)
0
10
20
150
200
250
300
350



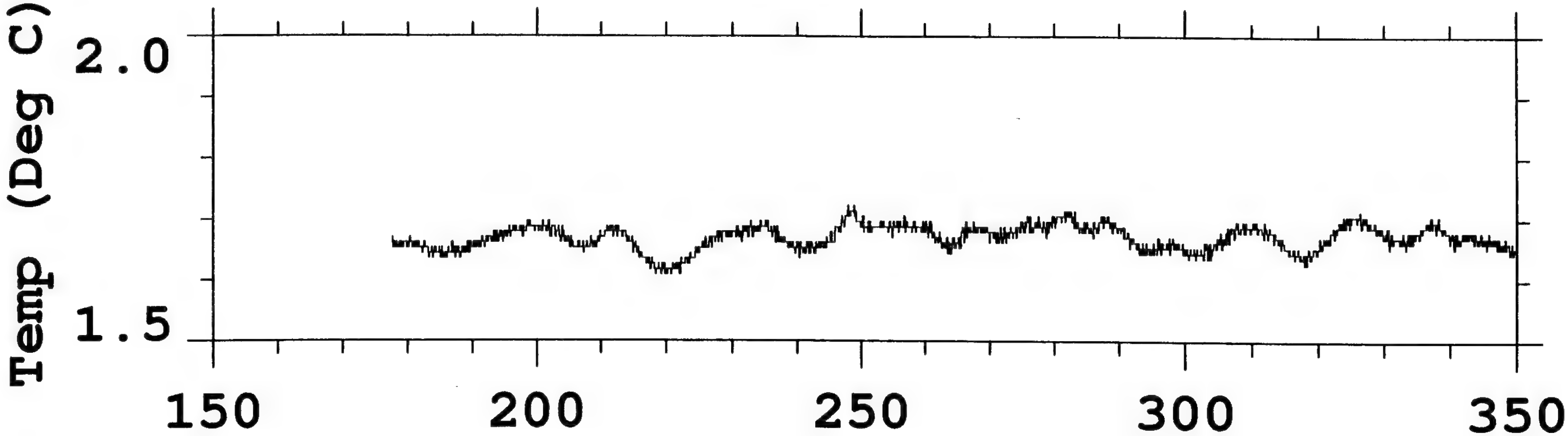
Temp (Deg C)
0
10
20
350
400
450
500
550

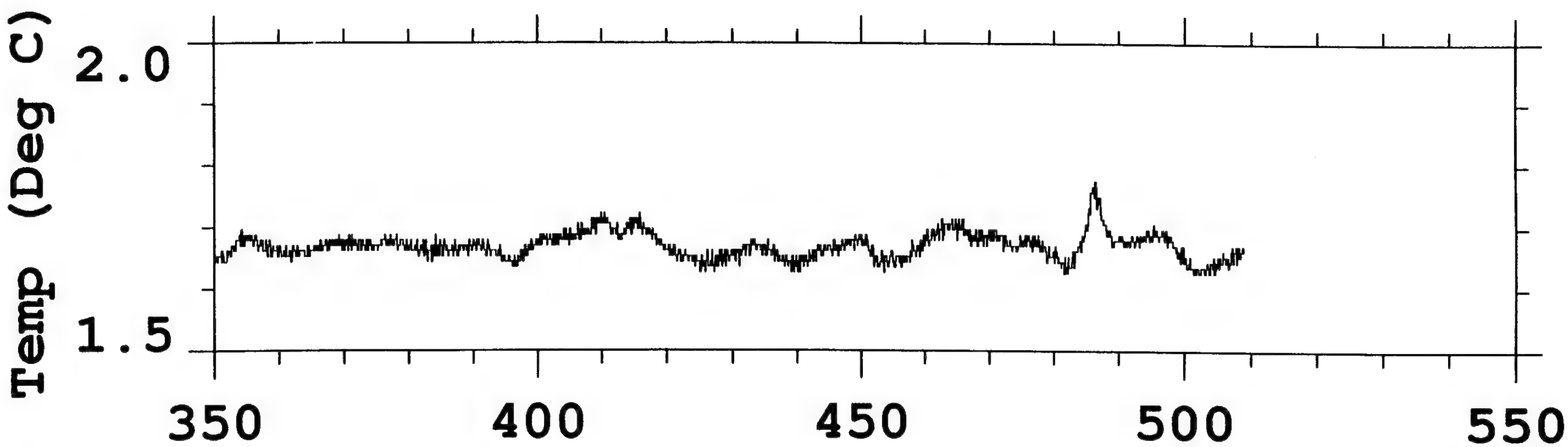
cm93d2



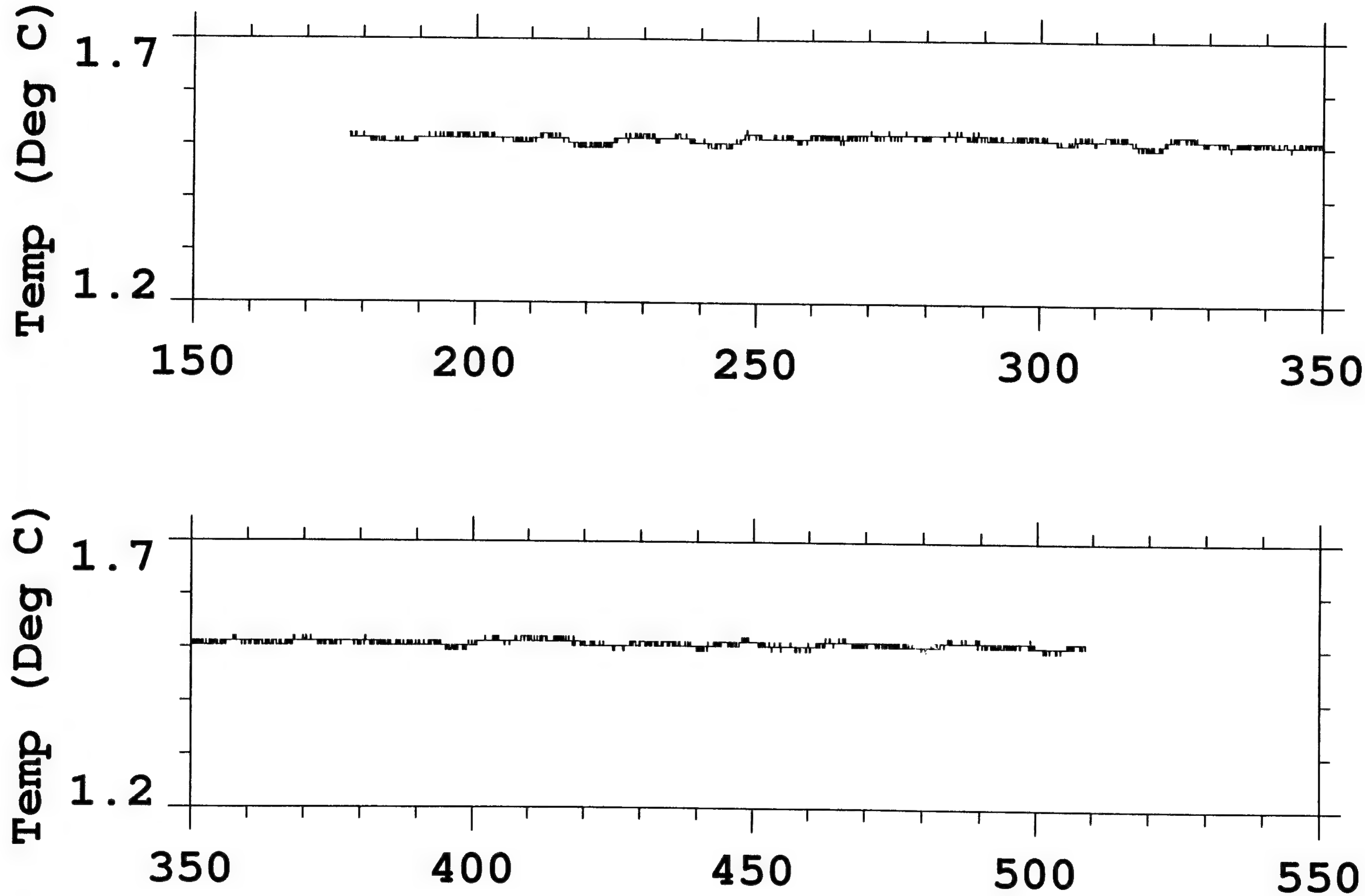
Temp (Deg C)
2.6
2.1
150
200
250
300
350
Temp (Deg C)
2.6
2.1
350
400
450
500
550

cm93d3


Temp (Deg C)
2.0
1.5
150
200
250
300
350

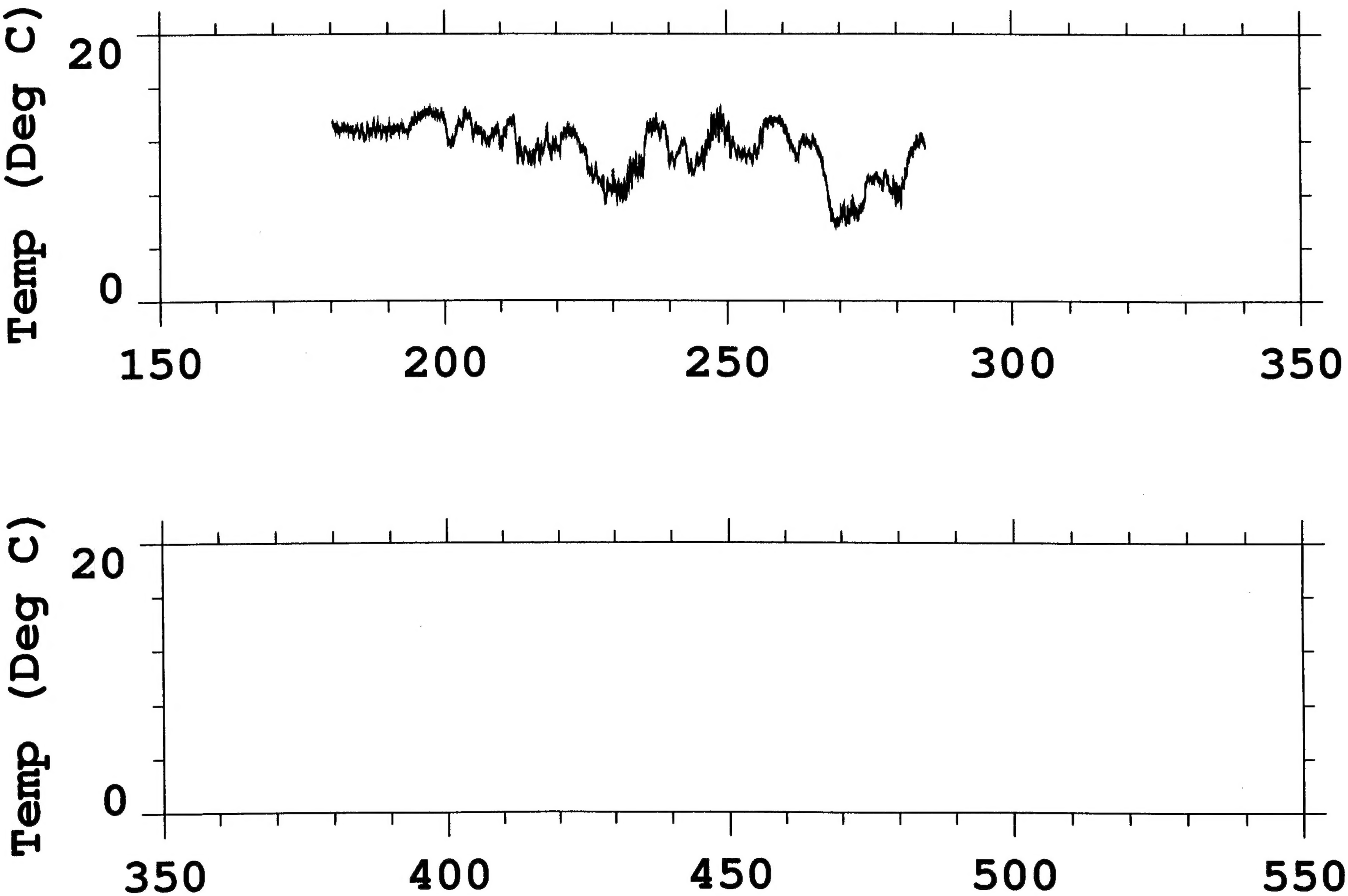

Temp (Deg C)
2.0
1.5
350
400
450
500
550

cm93d4



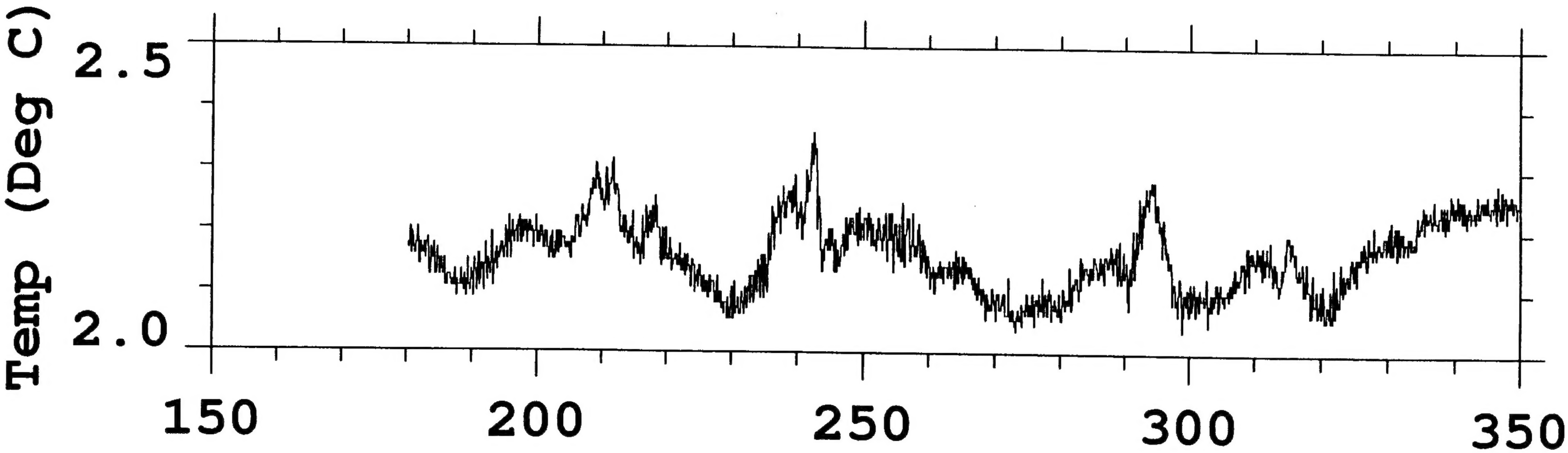
Temp (Deg C)
1.7
1.2
150
200
250
300
350
Temp (Deg C)
1.7
1.2
350
400
450
500
550

cm93e1

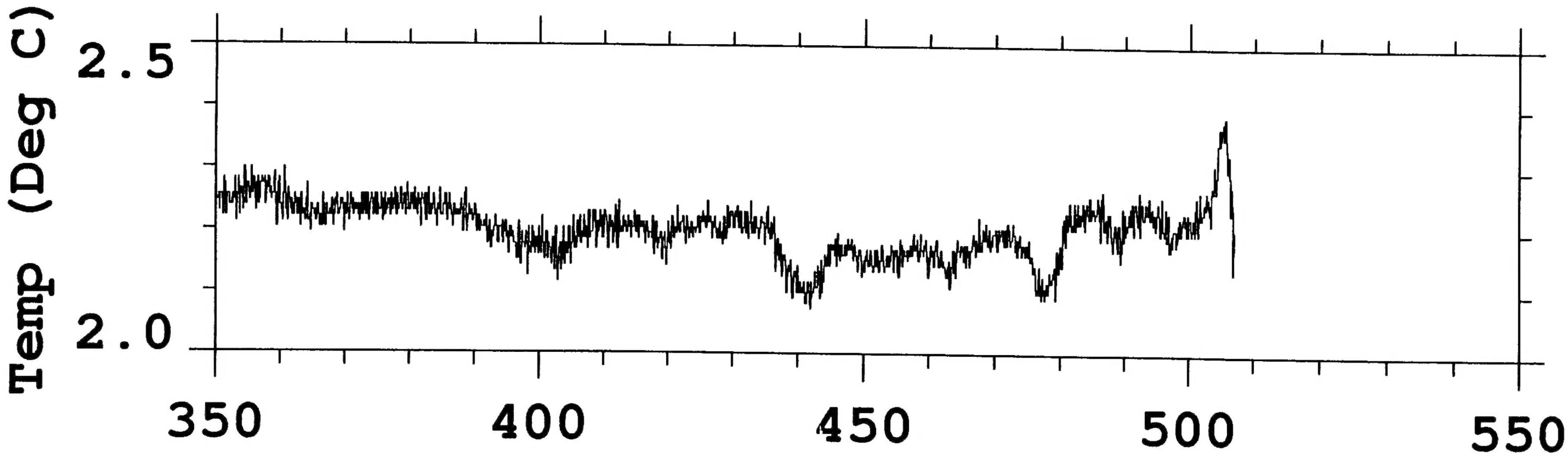


Temp (Deg C)
20
0
150
200
250
300
350
Temp (Deg C)
20
0
350
400
450
500
550

cm93e2

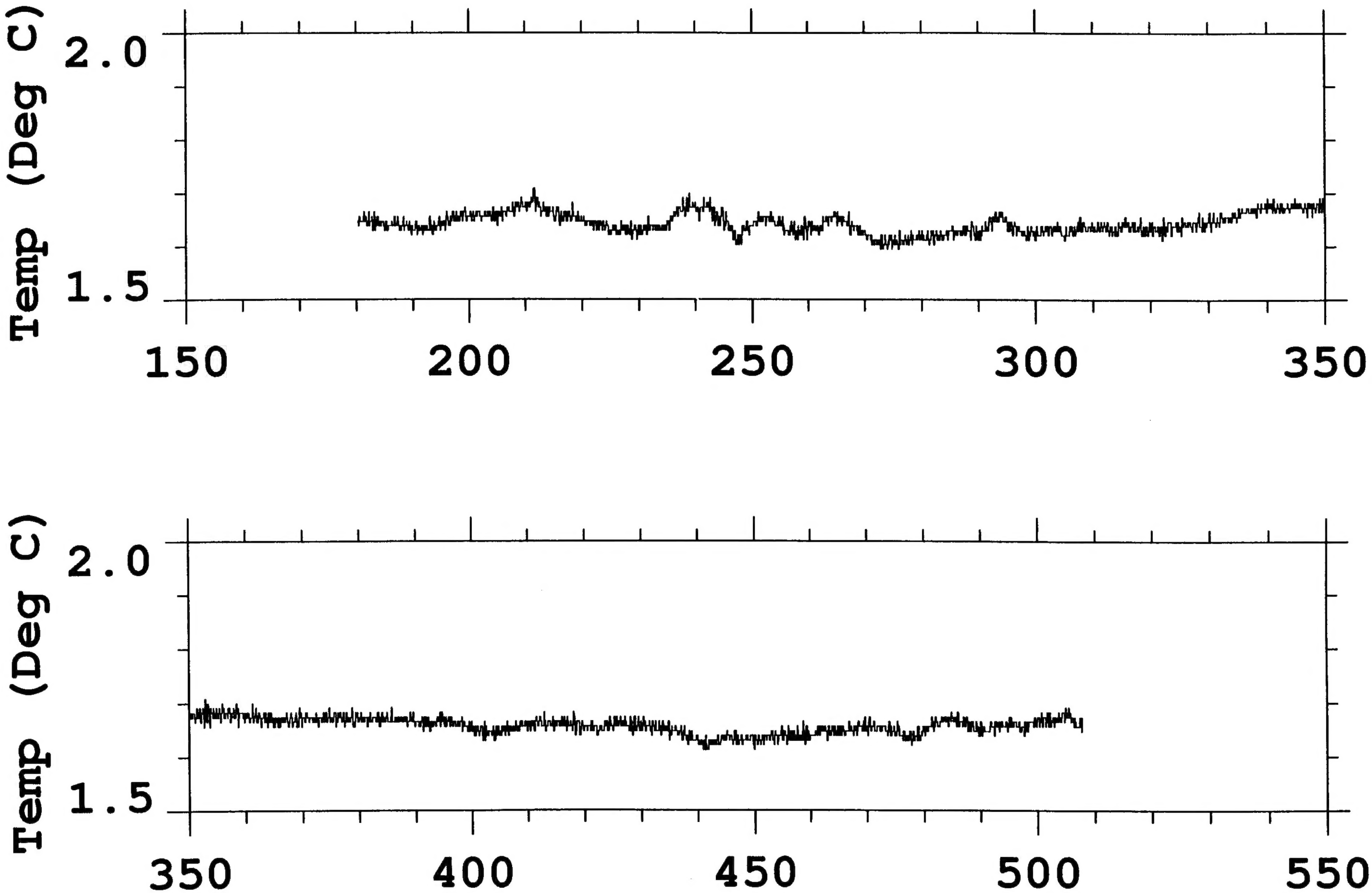


Temp (Deg C)
2.5
2.0
150
200
250
300
350



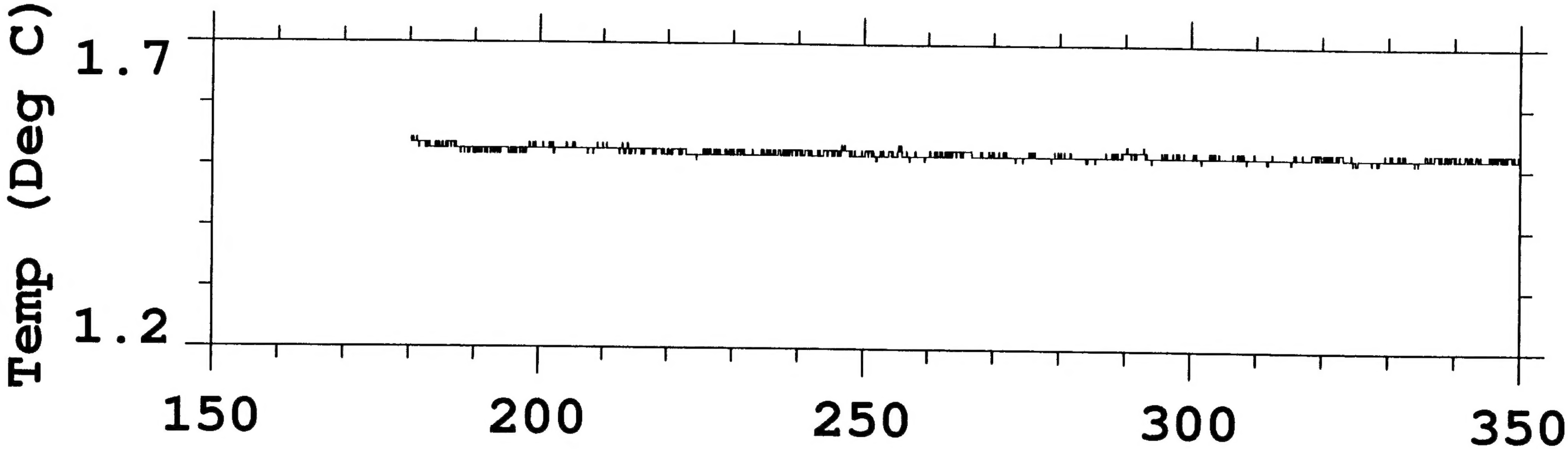
Temp (Deg C)
2.5
2.0
350
400
450
500
550

cm93e3

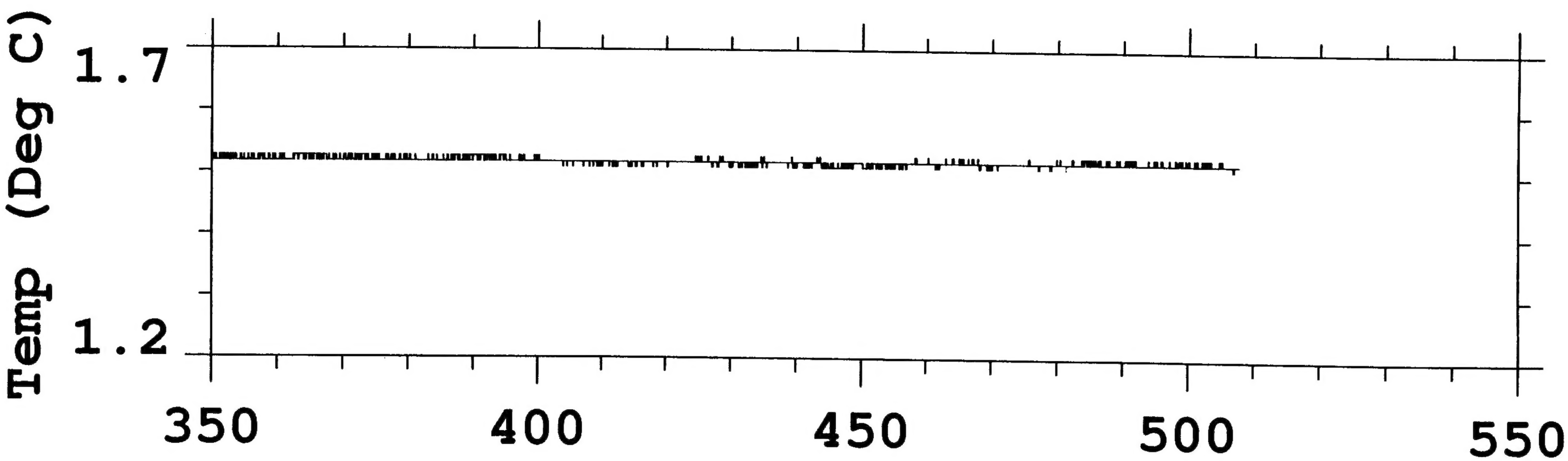


Temp (Deg C)
2.0
1.5
150
200
250
300
350
Temp (Deg C)
2.0
1.5
350
400
450
500
550

cm93e4



Temp (Deg C)
1.7
1.2
150
200
250
300
350



Temp (Deg C)
1.7
1.2
350
400
450
500
550